APPENDIX B

CLIMATE AND HYDROLOGY

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CHAPTER I GENERAL

This supporting report presents the results of the climatic and hydrological studies in the planning of sabo and flood control facilities. The purpose of the studies is broadly divided into three as follows:

(1) To grasp the general climatic conditions in the Study Area;
(2) To analyze past rainfall and flood records; and
(3) To estimate the probable flood discharge through a flood runoff model.

For these purposes, the Study was carried out in accordance with the following procedures:

(1) Data collection and field reconnaissance;

(2) Analysis of general climatic conditions including tropical cyclones, rainfall, temperature, humidity and wind;

(3) Mainly the analysis of rainfall and flood records, confirmation of availability of hydrological data, estimation of past major floods, proposal of a model hyetograph, and computation of basin mean rainfall;

(4) Calculation of flood runoff for the formulation of the flood runoff model and the estimation of probable flood discharge; and

(5) Installation of hydrological gauging equipment as provided in the Study.

CHAPTER II GENERAL CLIMATE

2.1 Climatic Classification in the Philippines

The climatic conditions in the Philippines are varied due to the existence of various plateaus and islands that differ in relief. Several climate classifications are commonly used by PAGASA and one of them is the Corona's classification (1920) which is based solely on rainfall characteristics. Using the average monthly distribution of rainfall and taking into consideration the greater or less prevalence of rain periods, climate of the Philippines is divided into four types as shown in Fig. B.2.1.

(1) Type I

There are two pronounced seasons: wet from May to October and dry for the rest of the year. All regions in the western part of the islands of Luzon, Mindoro, Negros, and Palawan belong to this type. The climate of the Study Area also falls under Type I.

(2) Type II

There is no dry season, and the maximum rain period is very pronounced from November to January. Regions of this type are along or very near the eastern coast and are not sheltered from the northeast monsoons, trade winds and storms.

(3) Type III

There is no pronounced season. It is relatively wet from May to October and dry the rest of the year. Maximum rain period is not very pronounced and the dry season lasts from one to three months.

(4) Type IV

Rainfall is evenly distributed throughout the year. The regions affected by this type are Batanes Province, Northeastern Luzon, the southwestern part of Camarines Norte, western part of Leyte, Northern Cebu, Bohol, and most of Central, Eastern and Northern Mindanao.

2.2 Climatic Features in the Study Area

(1) Tropical Cyclones

The major storms that occurred in the Philippine Area of Responsibility (PAR) have been due to tropical cyclones. Tropical cyclones are, by international agreement, classified as follows:

(a)	Tropical Depression (TD)	:	with maximum wind speed of up to 63 km/hr.
(b)	Tropical Storm (TS)	:	with maximum wind speed between 64 and 118 km/hr.
(c)	Typhoon (TY)	:	with maximum winds greater than 118 km/hr.

Fig B.2.2 shows the general tracks of tropical cyclones affecting the northern part of Luzon. The season of tropical cyclones in the Philippines is from May to January. Tropical cyclones form as early as April but these are relatively few in number. Most tropical cyclones usually form in the Pacific Ocean between the Philippines and the

Marianas-Carolinas Islands in the months of July to September. The cyclones deposit a large amount of rainfall while passing overland where their energy is gradually dissipated.

The number of tropical cyclones which occurred in the PAR is presented in Table B.2.1. During the past 48 years (1948-95), a total of 957 tropical cyclones hit or came close to the PAR, averaging 20 cyclones per year, and about 26 percent of them (250 cyclones) hit or came close to Northern Luzon. Around 3 cyclones a year brought to Laoag a maximum daily rainfall of more than 50 mm, 75 percent of which is concentrated in July to September.

Tracks of major cyclones which brought heavy rainfall and flood to the Study Area are presented in Fig. B.2.3. Most of the cyclones which brought major floods battered the northern part of the Study Area from southeast to northwest. All cyclones that affected the Study Area as well as the maximum daily rainfall at Laoag Station (PAGASA) are given in Table B.2.2.

(2) Rainfall

The Philippines experiences two types of monsoon winds, namely, the northeast and southwest monsoons. These monsoons are caused by thermal variations in the Asian mainland. During winter in the northern hemisphere, the Asian Continent is snow bound and the high pressure all over China sends northeasterly winds over the eastern coasts of the Philippines from November to February. During summer in the northern hemisphere, the Asian Continent becomes warmer than the surrounding seas and a low pressure cell develops over the continent. This causes a flow of moist southwest winds over the Philippines. When this southwest flow becomes thick in depth, it persists for a long period causing continuous rains which may last for weeks from June to September.

Thus, aside from tropical cyclones, the southwest monsoon is accountable for the great portion of rainfall during wet season. The southwest monsoon brings rainy season in the western coast, as well as in the Study Area, as shown in Fig. B.2.4.

The average annual rainfall in the Philippines is about 2,530 mm, while in the Study Area, rainfall records from the PAGASA Laoag Station indicate that the average annual rainfall during the period 1961 to 1995 amounted to 2,135 mm, 97 percent of which is concentrated in the wet season, May to October, as shown in Table B.2.3 and Fig. B.2.5.

(3) Temperature

The Philippines, situated in the tropics surrounded by warm seas, with warm air currents flowing over them, is expected to have a generally high temperature. Table B.2.4 and Fig. B.2.5 show the monthly maximum, mean and minimum temperature at the Laoag Station (PAGASA). Records indicate that, on the average, January is the coldest at 24.5°C and May is the warmest at 29.1°C; hence, the annual variation of temperature is small. The hottest months are April and May, while the coldest months are December to February. The annual mean temperature is around 27°C.

(4) Humidity

Throughout the Philippines, relative humidity is rather high. This condition is mainly a result of extensive evaporation from the seas surrounding the country, the moist air stream affecting the Philippines, and the large amount of rainfall. Table B.2.5 presents the monthly and annual relative humidity recorded at the PAGASA Laoag Station.

The annual average relative humidity at Laoag is about 78%. Fig. B.2.5 shows high relative humidity from June to October and low relative humidity from December to April.

(5) Wind

The winds are the composite of major air currents, cyclones and local circulation produced by diurnal and topographic effects. During the southwest monsoon season, winds are generally from the southwest quadrant especially along the western coastal areas including the Study Area and, specially in June to September, the area is influenced by southwest monsoons.

The wind direction over the Study Area tends to the north direction or northeasterly in October to February. With the incoming wet season, the winds blow from the northwest.

The average wind speed over the whole year ranges from 3 to 4 meters per second and large-scale wind variations are infrequent at the Laoag Station.

Table B.2.6 shows the monthly wind directions and wind speed at the Laoag Station.

(6) Evaporation

Table B.2.7 gives the mean monthly open pan evaporation observed at the Batac Station which is located 15 km south of Laoag City. The mean annual evaporation is 1,761.6 mm, and seasonal variations of mean monthly evaporation ranges from 120.1 mm in September to 186.6 mm in April. Records indicate that, on the average, the mean monthly evaporation is around 180 mm in dry season (March to May) and around 130 mm in wet season (June to September).

CHAPTER III RAINFALL AND FLOOD RECORD ANALYSIS

3.1 Availability of Hydrological Data

3.1.1 Rainfall Data

Rainfall observations relevant to the Study Area have been made through gauging stations under the control of PAGASA and NIA as shown in Fig B.3.1. The availability of data at these rainfall stations are given in Table B.3.1.

PAGASA operates two (2) stations: one near the Laoag International Airport and the other in Batac, Ilocos Norte. The Laoag Station, equipped with an automatic recorder and daily rainfall gauge, has been in operation since 1961, while the Batac Station has been operating a daily rainfall gauge since 1977. The Data Information Center (DIC) of PAGASA in Manila undertakes the collection and processing of these data. Some missing daily rainfall data of the Laoag station are supplemented by the automatic recorder. However, some data are still missing even after processing of the automatic recorder.

NIA had carried out daily rainfall observation from 1976 to 1983 at five (5) stations in the Study Area, namely, Manalpac, Lumbad, Alabaan, Quiom and Paoay. Furthermore, NIA has maintained since 1984 daily rainfall gauges at five irrigation dam sites, namely., the Labugaon, Solsona, Madongan, Papa and Nueva Era dams. Residents who live near these rainfall stations are assigned as gauge keepers, and they carry out manual measurement of rainfall. Data of these stations are compiled in NIA, Laoag, but these records are fragmentary.

Before the Study was started, rainfall data of the Laoag Station (PAGASA) were the only available in the estimation of probable flood discharge due to its long observation period and reliability. JICA had installed three (3) automatic rainfall gauging equipment in Piddig, Solsona and Nueva Era as shown in Fig B.3.2.

3.1.2 Water Level and Discharge Data

The DPWH since 1957 has been conducting data collection on streamflow in the Study Area at three (3) stations, namely, Gilbert Bridge, Cauplasan Bridge and Solsona Dam as shown in Fig B.3.1. The inventory of water level and discharge data by DPWH is given Table B.3.2.

The gauge keepers who live near the stations have been observing the water level three times a day, i.e., from 7 to 8 a.m., around 12 noon and from 5 to 6 p.m.. The average of these data is recorded as daily water level data. The DPWH Region I Office has been undertaking discharge observations at these stations, but observation has not been carried out for the past 10 years.

Discharge observations had been performed only at the time of low river stage; hence, river stage-discharge relations are not precise for the high water stage. At present, observation at the Cauplasan Bridge ceased. Whole data on streamflow are available at the Bureau of Research and Standard (BRS), DPWH. Some daily records, however, especially the water level during flood time at Solsona Dam, are not available.

NIA had also observed daily discharge at the five (5) dam sites from 1978 to 1994 but only the average monthly discharge is recorded in NIA, Laoag. The records are fragmentary as tabulated in Table B.3.3.

For the Study, JICA had constructed three (3) automatic water level gauging stations including automatic current meters at Gilbert Bridge (Laoag River), Cauplasan Bridge (Laoag River), and Solsona Dam (Solsona River) as shown in Fig B.3.2.

3.1.3 Tidal Water Level

Based on the Predicted Tide and Current Tables published by the National Mapping and Resource Information Authority (NAMRIA), DENR, 1996, the tidal data at Currimao Port which is the nearest to the Study Area and which is 20 km south of Laoag City is available for the Study. The tidal data and the results of the topographic survey conducted for the Study shows the relation between the tidal data at Currimao Port and the elevation of the National Bench Mark which is the basis of the topographic elevation in the Study Area as illustrated in Fig B.3.3. The relations are tabulated as follows:

Item No.	Water Level	Elevation (m)
1	Mean Spring Higher High Water (MSHHW)	+0.134
2	Mean Higher High Water (MHHW)	-0.018
3	Mean Sea Level (MSL)	-0.302
4	Mean Low Water (MLW)	-0.586

3.2 Flood Record Analysis

Flood record analysis has been carried out by the following procedures:

(1) Selection of major floods from past records;

(2) Estimation of flood probability by the probable water level/discharge at Gilbert Bridge. Estimation of flood probability from probable rainfall is not reliable, because there is only one station (Laoag station) in the Study Area where rainfall records for a long period were obtained; and

(3) Evaluation of the selected major floods by the estimated flood probability.

3.2.1 Selection of Major Flood

Availability of rainfall and water level data is explained in Section 3.1, Availability of Hydrological Data. Based on the rainfall and water level data, the selection of major floods is conducted in line with the following conditions:

(1) Maximum five (5) water level records at Gilbert Bridge on Laoag River.

(2) Maximum five (5) flood inundation depth above the road by interview survey.

(3) Maximum five (5) rainfall data at Laoag Station for various durations such as 3 hrs., 6 hrs., 12 hrs., 1 day, 2 days and 3 days.

(4) Maximum three (3) flood marks at five (5) irrigation dams, namely, Labugaon, Solsona, Madongan, Papa and Nueva Era.

A total of sixteen (16) major floods are selected as presented in Table B.3.4. Among these major floods, six (6) floods with a higher flood level are selected. The table below shows the six highest flood levels.

	Cyclone	Water Level at Gilbert Br.	Rainfall at Laoag (mm) 1-day	2-day	3-day
1	Gening, Jun 1967	9.9 m	510	557	558
2	Wanda, Aug 1962	9.8 m	409	468	496
3	Miding, Sep 1986	9.4 m	214	350	476
4	Gloring, Jul 1996	9.3 m	382	519	674
5	Maring, Sep 1992	9.0 m	265	450	467
6	Goring, Jul 1977	8.9 m	240	306	347

3.2.2 Probable Water Level and Discharge

DPWH had recorded the water level in Laoag River at Gilbert Bridge for 37 years from 1959 to 1995. The annual maximum water levels which are converted to the datum for the Study are given in Table B.3.5. No water level data is available from 1978 to 1983, but it may be noted that there were no heavy rainfall and big flood damage during this period.

The probability plot of water level at Gilbert Bridge is computed from Table B.3.5 and the rating curve is obtained from the records of Typhoon Gloring in July 1996. The probability plot of water level and rating curve are shown in Fig. B.3.4. Based on the calculation, the probable water level in terms of elevation and discharge at Gilbert Bridge is shown below.

Return Period	Water Level (EL.m)	Discharge (m^3/s)
2-yr.	6.85	4,500
5-yr.	8.29	7,200
10-yr.	9.06	8,900
25-yr.	9.90	10,900
50-yr.	10.44	12,300
100-yr.	10.94	13,700

3.2.3 Evaluation of Major Floods

The probability of major floods recorded from 1959 including Typhoon Gloring in July 1996 is listed below.

	Cyclone	At Gilbert Bridge Water Level	Discharge	Probability of Flood
1	Gening, Jun 1967	9.9 m	10,900 m^3/s	25-yr.
2	Wanda, Aug 1962	9.8 m	10,800 m^3/s	24-yr.
3	Miding, Sep 1986	9.4 m	9,700 m^3/s	15-yr.
4	Gloring, Jul 1996	9.3 m	9,500 m^3/s	15-yr.
5	Maring, Sep 1992	9.0 m	8,700 m^3/s	10-yr.
6	Goring, Jul 1977	8.9 m	8,500 m^3/s	9-yr.

Typhoon Gloring in July 1996 is evaluated to correspond to a flood of a 15-year return period. The biggest typhoon for the past forty years is typhoon Gening in June 1967 which corresponds to a flood of a 25-year return period.

3.3 Rainfall Analysis

Hourly rainfall distribution is indispensable to obtain the hydrograph of a probable flood discharge. Among the major floods mentioned above, only Typhoon Gloring in July 1996 gives the hourly rainfall distribution records of the four stations of Laoag, Piddig, Solsona and Nueva Era.

A point rainfall distribution pattern or a model hyetograph is proposed based on the rainfall records of Typhoon Gloring in July 1996. Furthermore, basin mean rainfall is computed to estimate the temporal and spatial rainfall distributions in the Study Area.

3.3.1 Model Hyetograph

During the Study, Typhoon Gloring hit Northern Luzon and triggered a heavy downpour in the Study Area from July 23 to July 27, 1996. Fig. B.3.5 shows the track of the typhoon. Heavy rainfall took place when the eye of the typhoon was crossing 200 km north of Laoag City.

The hyetograph recorded at the four rainfall gauging stations is shown in Fig. B.3.6. The maximum rainfall amount for the duration of 5 days, 3 days and 1 hour at these stations are given below.

Rainfall Station	5-day Rainfall[1] (Jul. 23 - Jul.27)	3-day Rainfall[2] (Jul. 24 - Jul.26)	Maximum Hourly Rainfall	
Laoag	705 mm	643 mm	51 mm	15:00 - 16:00, Jul. 25
Piddig	786 mm	741 mm	69 mm	16:00 - 17:00, Jul. 25
Solsona	689 mm	594 mm	30 mm	12:00 - 13:00, Jul. 25
Nueva Era	829 mm	795 mm	52 mm	12:00 - 13:00, Jul. 25

1): 5-day means from 8 a.m. on July 23 to 8 a.m. on July 28, 1996.
2): 3-day means from 12 midnight on July 23 to 12 midnight on July 26, 1996.

Rainfall was concentrated for three days, from midnight of July 23 to midnight of July 26, 1996. The observed rainfall distribution pattern for three days is proposed as the model hyetograph to estimate the hydrograph of a probable flood discharge as shown in Fig. B.3.7. However, the hyetograph at Solsona adopts the average hourly distribution pattern of Piddig and Nueva Era because the rainfall amount at Solsona, especially the hourly maximum rainfall is too small compared to the others.

3.3.2 Basin Mean Rainfall

The proposed model hyetograph which is a point rainfall at each station is converted to basin mean rainfall by the Thiessen polygon method with the altitude conversion factor. Taking the following formula into account, basin mean rainfall is estimated;

$$R_m = f \cdot R_0$$

where;

R_m : basin mean rainfall
R_0 : point rainfall
f : conversion factor

$f = f_t \cdot f_e$

where;

f_t : Thiessen coefficient
f_e : altitude adjustment factor

(1) Thiessen Polygon Coefficient

Thiessen polygons and coefficients of sub-basins are given in Fig. B.3.8. Division of basin is described in Section 4.1, River System Model.

(2) Altitude Conversion Factor

Since the four (4) automatic rainfall stations are not located at the average elevation of each sub-basin, the rainfall amount is adjusted by elevation or altitude.

The relationship between the rainfall amounts of various duration (1-hr, 3-hr, 12-hr and 24-hr) and the elevation is derived from five rainfall stations (PAGASA) in western Luzon, namely, Laoag, Vigan, Dagupan, Baguio and Sta. Cruz, with various elevations (3 m to 1,500 m) as shown in Fig. B.3.9, assuming that climatic conditions are similar.

The point rainfall amount is adjusted for the rainfall duration of 3-hr and 24-hr by the altitude conversion factor as shown in Fig. B.3.9: The altitude conversion factor is expressed by the following equation:

f_e = EXP [0.00035 h] (rainfall duration = 3-hr.)
f_e = EXP [0.00043 h] (rainfall duration = 24-hr.)

where;

f_e : altitude conversion factor
h : altitude or elevation (m)

Table B.3.6 gives the altitude conversion factor. The altitude conversion factor is applied considering the average elevation of each sub-basin and the elevation of rainfall stations.

3.3.3 Probable Rainfall

The probable rainfall obtained from the rainfall records of only one station in the Study Area (Laoag Station) is not reliable to estimate the probability of flood, but it is still computed as a secondary data.

(1) Computation of Probable Rainfall

Data of the PAGASA Laoag Station are used to estimate the probable rainfall because the station is the only available and reliable source. The recorded maximum rainfall of 1-day, 2-day and 3-day duration at the station are tabulated in Table B.3.7. Probable maximum rainfall of 1-day, 2-day and 3-day durations are computed by the Hazen, Gumbel, Log-normal, Iwai, Ishihara-Takase methods as presented in Table B.3.8. Fig. B.3.10 presents the probability graphs of exceedance of 2-day duration using the Log-normal method which fit well in the rainfall data plotted by the Hazen method. Results of the Log-normal method are summarized below.

(Unit: mm)

Return Period	1-day	2-day	3-day
2-yr.	226	325	377
5-yr.	321	450	516
10-yr.	387	534	608
25-yr.	471	641	725
50-yr.	535	721	811
100-yr.	600	801	898

(2) Storm Rainfall Duration

The duration of storm rainfall is an important factor in setting up the hyetograph for the hydrological design. It has been confirmed by the rainfall mass curves prepared by using hourly rainfall records of big storms, as presented in Fig. B.3.11. Most of the storm rainfalls that triggered a high water level at Gilbert Bridge ceased after 2 days. In the case of Typhoon Gloring, the hyetograph of 2-day duration, from July 24 to July 25, brought a peak discharge in the Study Area as shown in Fig. B.4.4.

(3) Estimation of Flood by Probable Rainfall

Since storm rainfall brought major floods after two (2) days, a major flood is estimated by a 2-day probable rainfall. The major floods in Subsection 3.2.3, Evaluation of Major Floods, were estimated by probable rainfall as follows:

	Cyclone	2-day Rainfall at Laoag Station	Probability
1	Gening, Jun 1967	557 mm	
2	Wanda, Aug 1962	468 mm	
3	Miding, Sep 1986	350 mm	
4	Gloring, Jul 1996	519 mm	
5	Maring, Sep 1992	450 mm	
6	Goring, Jul 1977	306 mm	

Typhoon Gloring in July 1996 corresponds to around 10-year return period by probable rainfall.

CHAPTER IV FLOOD RUNOFF CALCULATION

4.1 River System Model

A river system model is constructed for the flood runoff analysis of different river basins according to shape, stream network and topography. The model in the Laoag River Basin comprises all the elements of a river system such as sub-basin and channel. Fig. B.4.1 presents the basin divisions and area of sub-basins which are constructed considering the following locations:

(1) The junction of main stream with major tributaries;

(2) The existing streamflow gauging stations;

(3) The river section bounding catchments with different runoff characteristics; and

(4) The existing and proposed river structure sites.

The Laoag River Basin is divided into 24 sub-basins related to 19 river channels. Based on the basin divisions, the river system model for the runoff calculation is as shown in Fig. B.4.2 and illustrated in Fig. B.4.3.

4.2 Runoff Model

4.2.1 Formulation of Runoff Model

The Storage Function Method is employed for the flood runoff computation in this study to express the non-linearity of runoff phenomena. The storage function method can show the process of transformation from rainfall to runoff on the assumption that there is a one-on-one functional relation between the volume of storage and runoff.

Through the use of this method, a relationship can be established between the volume of storage (*S*) of a basin or river channel and discharge (*Q*). This relationship is expressed as:

$$S = K \cdot Q^{p} \qquad \text{(K, p: constant)}$$

This equation is used with the equation of motion which expresses runoff as proportional to the exponent of storage volume. In this equation, runoff phenomena is considered to be similar to the runoff from the notch of a container filled with water.

(1) Storage Function Model for River Basin

Runoff calculation for a basin is performed in combination with the following equation of continuity.

$$dS/dt = 1/3.6 \cdot f \cdot r_{ave} A - Q$$

where;

S	:	apparent storage volume in the basin (m3/s/hr)
f	:	inflow coefficient
r_{ave}	:	basin's average rainfall (mm/hr)
A	:	area of the basin (km^2)
$Q(t) = Q(t+T)$	:	direct runoff height with lag time (m^3/s)
T	:	lag time (hr.)

Constants K, p and T for a river basin are determined as follows:

$$K = 2.5\,k\,A^{0.24}$$
$$p = 0.6$$
$$T = 0.0506\,L - 0.31$$

where;

A	:	catchment area (km^2)
L	:	channel length (km)
k	:	constant of surface flow ($k = (N/I^{0.5})^{0.6}$)
I	:	slope of surface
N	:	equivalent roughness coefficient

Land Condition	Equivalent Roughness Coefficient (N)
Paddy field (Farm)	2
Mountain, Forest	0.7
Hill	0.3

The constants K and T are given in Table B.4.1. The constant f in the above equation is the inflow coefficient and is used to estimate the effective rainfall. In the Storage Function Model, the coefficient f is not related to rainfall but to the drainage area. It is assumed that in the early stages of rainfall, f is f_1 (termed the primary runoff rate) and that runoff occurs only from the area $f_1 \times A$ (called the runoff area). When Rsa (saturation rainfall) accumulate, then $f = 1$ (this is termed as the saturation runoff rate), and runoff occurs also from the remaining part $(1 - f_1) \times A$ (infiltration area) due to the rainfall after Rsa. In this Study, the constants f_1 and Rsa are fixed at 0.5 mm and 100 mm, respectively.

(2) Storage Function Model for River Channel

The storage function of the channel is performed in combination with the following equation:

$$dS/dt = \Sigma fj \cdot Ij - Q_l$$

where;

S	:	apparent storage volume of river channel (m^3)
Ij	:	inflow from the upstream end of a river course to the river channel being considered (m^3/s)
fj	:	Inflow coefficient
$Q_l(t)=Q(t+T)$	:	discharge at the downstream end of basin under the consideration of lag time (m^3/s)
T	:	lag time (hr.)

Constants K, p and T for river channel are determined as follows:

$$K = LB^{0.4}\ (n / I^{0.5})^{0.6} / 3.6$$

$$p = 0.6$$

$$T = 0.00165 L I^{0.5}$$

where;

B	:	average channel width (m)
L	:	channel length (km)
n	:	Manning's roughness coefficient
I	:	average channel slope

K and P for river channels are determined assuming the flow as Manning's uniform flow. The determined constants K and T are given in Table B.4.1.

4.2.2 Verification of Runoff Model

The flood runoff model formulated in the previous Subsection 4.2.1 is verified from the viewpoint of conformity of the computed or simulated runoff hydrograph with the observed discharge hydrograph. The computed hydrograph using the proposed runoff model of Typhoon Gloring in July 1996 is verified with the observed hydrograph. The observed point rainfall for the runoff calculation is converted to basin mean rainfall by the Thiessen coefficient and the altitude and areal conversion factors explained in Subsection 3.3.2, Basin Mean Rainfall.

Fig. B.4.4. shows the comparison of the computed and observed hydrographs at Gilbert Bridge, Cauplasan Bridge and Solsona Dam. The comparison indicates that the computed peak discharge and proposed runoff model are appropriate to estimate the probable discharge. The peak discharges compared are as follows:

Location	Discharge (m^3/s)	
	Observed	Computed
Solsona Dam	550	630
Cauplasan Br.	4,800	5,000
Gilbert Br.	9,500	8,800

4.3 Probable Flood Discharge

Probable flood discharges are computed for 2, 5, 10, 25, 50 and 100-year return periods in accordance with the following procedures:

(1) Obtain a peak discharge at Gilbert Bridge from the proposed model hyetograph shown in Fig. B.3.7;

(2) Compute a probable flood discharge after expanding or contracting the model hyetograph. The probable flood discharge at Gilbert Bridge should correspond to the probable water level and discharge estimated in Subsection 3.2.2; and

(3) Verify the computation results comparing it with other study results in the Study Area and other river basins in the Philippines.

4.3.1 Peak Discharge Computed from Model Hyetograph

Based on the proposed model hyetograph shown in Fig. B.3.7, the basin mean rainfall of each sub-basin is calculated considering the Thiessen polygon coefficient and the altitude and areal conversion factors. The basin mean daily rainfalls are tabulated in Table B.4.2. (Refer to Subsections 3.3.1 and 3.3.2.)

The peak discharge at Gilbert Bridge computed from the basin mean rainfall is shown in the following Table.

Peak Discharge	Return Period
10,500 m^3/s	around 20-year

The peak discharge computed from the proposed model hyetograph corresponds to around 20-year return period.

4.3.2 Computation of Probable Flood Discharge

After expanding or contracting the model hyetograph, the probable flood discharges corresponding to 2, 5, 10, 25, 50 and 100-year return periods are computed. The results are presented in Fig. B.4.5, and the flood discharges and water levels at Gilbert Bridge are shown below.

Return Period	Expand/Contract Rate	Water Level (EL.m)	Flood Discharge (m^3/s)
2-yr.	0.50	6.85	4,500
5-yr.	0.72	8.29	7,200
10-yr.	0.86	9.06	8,900
25-yr.	1.03	9.90	10,900
50-yr.	1.15	10.44	12,300
100-yr.	1.26	10.94	13,700

The hydrograph of the probable flood discharges at Gilbert Bridge is shown in Fig. B.4.6.

4.3.3 Verification of Probable Flood Discharge

The probable flood discharge in the Study Area had been previously computed in the following studies:

(1) The Detailed Design on Ilocos Norte Irrigation Project, NIA, 1981

(2) The Nationwide Flood Control Plan and River Dredging Program, DPWH, 1982

(3) The Feasibility Study on the Tina-Gasgas-Cura Impounding Reservoir Project at Solsona, NIA, 1983

The probable flood discharges in this present Study and the studies mentioned above are tabulated in Table B.4.3 and compared in Fig. B.4.7. The discharges from upstream sub-basins of this Study are almost the same or slightly larger than those of the other studies. Although the discharge at Gilbert Bridge in this Study is larger than that of the other studies, the probable discharge verified in Subsection 3.2.2, Probable Water Level and Discharge, justifies the appropriateness of flood discharges computed in this Section 4.3.

The specific discharges of a 50-year return period are compared with those estimated for other river basins, as shown in Fig B.4.8. The estimated specific discharge in this Study is larger than those of the other river basins, because rivers in the Study Area have a steeper slope and has no flat or retarding area like those of the other river basins.

Furthermore, the probable discharge is estimated through the probable rainfall which corresponds to a 25-year return period. The probable 2-day rainfall of a 25-year return period is 641 mm in accordance with the Subsection 3.3.3, Probable Rainfall. The 2-day rainfall of Typhoon Gloring is 519 mm. The model hyetograph shown in Fig. B.3.7 is expanded by the ratio of rainfall amounts of 641 mm to 519 mm which is 1.24. The probable peak discharge is calculated by the expanded hyetograph considering its basin mean rainfall, as shown below.

Peak Discharge	Water Level
13,400 m^3/s	10.9 m

This peak discharge corresponds to the water level of 10.9 m which is equivalent to a 90-year return period based on the probable flood discharge estimated in Subsection 3.2.2, Probable Water Level and Discharge. This peak discharge is not appropriate for this present Study.

CHAPTER V INSTALLATION OF HYDROLOGICAL GAUGING EQUIPMENT

Under this Study, three (3) rainfall and three (3) stream flow gauging stations have been constructed at different sites, as indicated in Fig B.3.2.

5.1 Rainfall Gauging Stations

5.1.1 Location

(1) Piddig Rainfall Gauging Station

Piddig Rainfall Gauging Station is located on top of a small hill inside the campus of Don Salustiano High School, Piddig, Ilocos Norte (Coordinates: N18 10'44.3", E120 43'28.5").

(2) Solsona Rainfall Gauging Station

This rainfall gauging station is located at the left side of the road on a small hill along Solsona-Kalinga-Apayao Road, leading to the boundary of Ilocos Norte and Kalinga-Apayao. (Coordinates: N18 05'53.4", E120 49'56.5").

(3) Nueva Era Rainfall Gauging Station

This Station is located in front of the Municipal Hall of Nueva Era and within the municipal garden of the said town. (Coordinates: N17 54'56.5", E120 39'49.3").

5.1.2 Configuration of Equipment

The rainfall gauges installed are all identical unit types (Model B-432-01) as shown in Fig B.5.1. Each equipment is an automatic type designed for automatic measurement and recording of rainfall for over one month. This is operated mainly by one dry battery with a power of 1.5V.

The equipment has a single body which stores the sensor and the recorder. Rainwater enters into the inlet and it is collected in one of the two buckets. When a fixed amount of rain, 0.5 mm, is collected, the bucket apparatus tips and the collected rain is drained out at the bottom. The other bucket comes into position to collect rain, and the process is repeated.

The bucket apparatus tips at the fixed rainfall level, namely 0.5 mm, and the tipping movement is detected by the center axle of the tipping apparatus. This is transmitted with a cam linked to the recording pen. The corresponding rainfall is then recorded on the chart in a step format. If data recording reaches the edge of the chart, the recording continues by returning across the width of the chart. A quarts clock is used for the chart drive and can advance the chart at 18 mm/hour. One (1) roll of chart is sufficient to contain one (1) month rainfall data in continuos operation.

Fig B.5.2 shows the structural layout of a rainfall station. Fence with a height of 2.0 m made up of interlink wire is provided, and barbed wire is placed on top of the fence. The automatic rainfall gauge is mounted on a rectangular steel plate with steel pipe supports which is elevated at about 1.20 m and anchored to the ground on reinforced concrete.

A Public Notice Board is also placed beside the rain gauge fence with English message translated in Ilocano to inform the public of the use of such equipment. (Refer to Fig B.5.2.)

5.2 Stream Gauging Station

5.2.1 Location

(1) Gilbert Bridge Stream Flow Gauging Station

Sensors are installed at the upstream side of Gilbert Bridge (Coordinates: N18 12'12.1", E120 35'18.7") on Laoag River and 200 meters away from the approach to Laoag City. Gilbert Bridge is approximately 8.3 km away from the Laoag river mouth. The electric equipment house is located beside the bridge at the right bank, on the Laoag city side.

(2) Cauplasan Bridge Stream Flow Gauging Station

Sensors are installed at the upstream side of the bridge (Coordinates: N18 05'46.6", E120 42'47.9") and it is approximately 500 meters from the approach to the left bank, while the electric equipment house is constructed on the sidewalk of Cauplasan Bridge approximately 460 meters away from the left bank.

(3) Solsona Dam Streamflow Gauging Station

Sensors are installed at the right bank approximately 70 meters upstream of Solsona Dam (Coordinates: N18 15'10.8", E120 48'49.9"). The electric equipment house is constructed at the right bank of Solsona Dam Bridge near the field office of the National Irrigation Administrative (NIA).

5.2.2 Configuration of Equipment

The stream flow gauging stations have three (3) component sensors as shown in Fig B.5.3, namely; the radio wave current sensor, the ultrasonic water level sensor, and the temperature sensor which measures air temperature to adjust propagation speed of ultrasonic wave. Staff gauges are also installed at piers of Gilbert Bridge, Cauplasan Bridge and Solsona Dam.

Power in all equipment in the three (3) stations is supplied by the Ilocos Norte Electric Company (INEC). The power supplied is 220/240V. This power is dropped to 100V to meet the power requirement of the equipment, through the power supply unit. Two (2) 12V batteries with 200 amp and 100 amp, respectively, are provided to maintain the operation of these equipment in case of brownout.

A Public Notice Board is also placed beside the electric equipment house with English message translated in Ilocano to inform the public of the use of such equipment. (Refer to Fig B.5.6.)

(1) Gilbert Bridge Stream Flow Gauging Station

At the Gilbert Bridge Station, water level, current and temperature sensors are attached to an arm assembly made of galvanized cast iron pipes with a length of 2 m which is welded directly to the web of outer steel girder of the Gilbert Bridge. The current sensor has a depression angle of 30. (Refer to Fig B.5.4.)

The three (3) sensors are connected to the equipment installed in the electric equipment house by (3) three cables with a length of 200 m. The equipment related to water level measurement are the water level converter, IC memory card logger and pen recorder, while those for water velocity or current measurement are the current meter with memory card logger and pen recorder. Power supply unit for brownout is also installed in the electric equipment house. (Refer to Figs B.5.5 to B.5.6.)

The zero point of the water level is set at around 10 m below the water level sensor. The chart speed is set at 2 cm/hr., the lowest speed of the pen recorder and therefore, the chart with a length of 15 m can record one month data. Data recording intervals to the IC memory card for both water level and flow velocity is set at every 10 minutes and the IC memory card can accommodate one month data at this interval.

(2) Cauplasan Bridge Stream Flow Gauging Station

At Cauplasan Bridge Gauging Station, the sensors are also attached to an arm of two (2) meters long galvanized cast iron pipe assembly which is welded on top of the steel flange of the upstream girder of the bridge. The arm assembly can be rotated to adjust the sensors to the desired position, and it is placed approximately 11 m above the riverbed. (Refer to Fig B.5.4.)

The electric house is constructed on the same side as the sensors. It is located along the sidewalk of the bridge and is modified into a smaller unit to conform with the space requirement of the sidewalk. Charts and pen recorders are not provided for this station. Setup of equipment is the same as the Gilbert Bridge Station. (Refer to Figs B.5.5 to B.5.6.)

(3) Solsona Dam Stream Flow Gauging Station

At Solsona Dam Gauging Station, the ultrasonic wave water level sensor and radio wave velocity sensor are attached to an arm assembly 2.5 m in length, made up of galvanized cast iron pipe and which can be rotated to adjust the sensors to the desired position. The two sensors are installed on top of the reinforced concrete wall of the intake dam, which is 70 meters away from the constructed electric equipment house. (Refer to Fig B.5.4.)

The water level sensor and the velocity sensor are set at approximately 6 meters above the existing water level. Velocity sensor is installed with a 35 degree angle of depression and the temperature sensor is installed at the top of the electric house. (Refer to Figs B.5.5 to B.5.6.)

The same type of equipment as in the Gilbert Bridge Station is installed in the electric equipment house of Solsona Station. However, the recording interval in storing data in the memory card loggers for water level and velocity is set at every 5 minutes. Pen recorders are also provided at this station.

5.2.3 Datum Elevation of Stream Gauge

The establishment of a Datum Elevation plays a major role in the Study. At the beginning, elevations were obtained at different sites as part of the ground survey activity which were then reflected on the topographic map. This topographic elevations were reckoned from the existing National Bench Mark which is the basis of topographic elevations in the Study Area. Out of these, Datum Line was established in the major point of stream observation, namely, Gilbert Bridge, Cauplasan Bridge and Solsona Dam. The table below shows the Gauge Level and Datum Elevation of these three (3) stations.

Location	Gauge Level (m)	Datum Elevation (m)
Gilbert Bridge	0.0	0.0
Cauplasan	0.0	20.0
Solsona	0.0	110.0

Staff gauges on which the gauge levels were established are installed at the piers of Gilbert Bridge and Cauplasan Bridge. Another gauge is installed at the side of the concrete wall on which the arm assembly of sensors is attached in the vicinity of Solsona Dam.

These staff gauges are constructed of 2" wide by 1/4" thick flat bars which are fastened to the piers and concrete walls of the stations. Graduations are painted and stickers are pasted on the flat bar to indicate the rise in elevation per meter. These are constructed to facilitate the observation of water level elevation especially during flood time.

TABLES

Table B.2.1 Number of Tropical Cyclones (1984 - 1995)

Year	Philippines	Northern Luzon																				
		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Others	Annual	
1948	20	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	6	(-)
1949	22	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	1	(-)	-	(-)	-	(-)	1	(-)	-	4	(-)
1950	14	0	(-)	0	(-)	0	(-)	0	(-)	1	(-)	1	(-)	1	(-)	0	(-)	0	(-)	0	3	(-)
1951	13	-	(-)	-	(-)	-	(-)	1	(-)	1	(-)	2	(-)	-	(-)	-	(-)	-	(-)	-	5	(-)
1952	27	-	(-)	-	(-)	1	(-)	1	(-)	2	(-)	-	(-)	-	(-)	2	(-)	-	(-)	-	8	(-)
1953	18	-	(-)	1	(-)	-	(-)	-	(-)	2	(-)	1	(-)	-	(-)	1	(-)	-	(-)	-	6	(-)
1954	18	0	(-)	0	(-)	0	(-)	0	(-)	1	(-)	1	(-)	2	(-)	2	(-)	0	(-)	0	6	(-)
1955	15	-	(-)	-	(-)	-	(-)	-	(-)	1	(-)	1	(-)	-	(-)	-	(-)	-	(-)	-	3	(-)
1956	25	1	(-)	-	(-)	-	(-)	-	(-)	1	(-)	1	(-)	1	(-)	3	(-)	-	(-)	-	9	(-)
1957	15	-	(-)	-	(-)	1	(-)	1	(-)	-	(-)	3	(-)	-	(-)	1	(-)	-	(-)	0	7	(-)
1958	17	-	(-)	-	(-)	-	(-)	1	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	2	(-)
1959	18	0	(-)	0	(-)	0	(-)	0	(-)	1	(-)	1	(-)	0	(-)	1	(-)	0	(-)	0	3	(-)
1960	19	1	(-)	1	(-)	-	(-)	-	(-)	1	(-)	1	(-)	1	(-)	-	(-)	-	(-)	-	6	(-)
1961	23	0	(0)	1	(0)	0	(0)	2	(2)	4	(2)	0	(0)	0	(0)	0	(0)	0	(0)	0	7	(4)
1962	21	0	(0)	1	(0)	0	(0)	2	(2)	1	(1)	0	(0)	0	(0)	0	(0)	0	(0)	0	4	(3)
1963	16	0	(0)	0	(0)	2	(1)	1	(1)	1	(0)	1	(1)	0	(0)	0	(0)	0	(0)	0	5	(3)
1964	32	0	(0)	0	(0)	0	(0)	0	(0)	1	(1)	3	(2)	2	(0)	1	(0)	0	(0)	0	7	(3)
1965	21	0	(0)	1	(1)	1	(1)	3	(1)	1	(1)	0	(0)	0	(0)	0	(0)	0	(0)	0	6	(4)
1966	22	0	(0)	3	(1)	1	(0)	0	(0)	3	(2)	3	(2)	0	(0)	0	(0)	0	(0)	0	10	(5)
1967	21	1	(1)	0	(0)	1	(1)	0	(0)	3	(3)	0	(0)	1	(1)	0	(0)	0	(0)	0	6	(6)
1968	15	0	(0)	0	(0)	0	(0)	1	(1)	2	(2)	2	(2)	0	(0)	1	(0)	0	(0)	0	6	(5)
1969	15	0	(0)	0	(0)	0	(0)	2	(1)	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)	0	4	(3)
1970	21	0	(0)	0	(0)	0	(0)	0	(0)	1	(0)	3	(2)	0	(0)	0	(0)	0	(0)	0	4	(2)
1971	27	1	(0)	0	(0)	1	(0)	1	(1)	1	(1)	1	(1)	1	(1)	0	(0)	0	(0)	0	6	(4)
1972	17	0	(0)	0	(0)	0	(0)	1	(1)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	1	(1)
1973	12	0	(0)	0	(0)	1	(0)	1	(1)	1	(1)	1	(0)	2	(2)	0	(0)	0	(0)	0	6	(4)
1974	23	0	(0)	0	(0)	1	(1)	0	(0)	1	(1)	1	(1)	4	(1)	1	(1)	0	(0)	0	8	(5)
1975	15	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	1	(0)	2	(2)	0	(0)	0	(0)	0	3	(2)
1976	22	0	(0)	1	(1)	1	(1)	0	(0)	1	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	3	(2)
1977	19	0	(0)	0	(0)	0	(0)	2	(1)	0	(0)	3	(2)	0	(0)	0	(0)	0	(0)	0	5	(3)
1978	25	0	(0)	0	(0)	1	(1)	0	(0)	0	(0)	2	(0)	0	(0)	0	(0)	0	(0)	0	3	(1)
1979	22	0	(0)	0	(0)	0	(0)	3	(2)	1	(1)	0	(0)	1	(0)	1	(0)	1	(0)	0	7	(3)
1980	23	0	(0)	2	(0)	0	(0)	3	(3)	1	(0)	0	(0)	0	(0)	1	(0)	0	(0)	0	7	(3)
1981	23	0	(0)	0	(0)	1	(1)	0	(0)	0	(0)	1	(1)	0	(0)	1	(0)	0	(0)	0	3	(2)
1982	21	0	(0)	0	(0)	0	(0)	1	(1)	1	(0)	0	(0)	1	(0)	0	(0)	1	(0)	0	4	(1)
1983	23	0	(0)	0	(0)	0	(0)	1	(0)	1	(1)	1	(1)	2	(0)	0	(0)	0	(0)	0	5	(2)
1984	20	0	(0)	0	(0)	0	(0)	2	(1)	2	(1)	0	(0)	1	(0)	1	(0)	0	(0)	0	6	(2)
1985	17	0	(0)	0	(0)	1	(1)	0	(0)	0	(0)	3	(0)	1	(1)	0	(0)	0	(0)	0	5	(2)
1986	21	0	(0)	1	(1)	1	(0)	1	(1)	1	(1)	0	(0)	1	(0)	0	(0)	0	(0)	0	5	(3)
1987	16	0	(0)	0	(0)	0	(0)	1	(0)	1	(1)	1	(1)	1	(1)	0	(0)	0	(0)	0	4	(3)
1988	19	0	(0)	0	(0)	1	(1)	1	(1)	0	(0)	1	(1)	1	(0)	0	(0)	1	(0)	0	5	(3)
1989	19	0	(0)	0	(0)	0	(0)	2	(1)	0	(0)	2	(2)	1	(0)	1	(0)	0	(0)	0	6	(3)
1990	20	0	(0)	0	(0)	2	(2)	0	(0)	2	(2)	1	(1)	0	(0)	0	(0)	0	(0)	0	5	(5)
1991	19	0	(0)	0	(0)	0	(0)	1	(1)	1	(1)	1	(1)	1	(1)	1	(0)	0	(0)	0	5	(4)
1992	16	0	(0)	0	(0)	0	(0)	2	(0)	0	(0)	1	(1)	0	(0)	0	(0)	0	(0)	0	3	(1)
1993	32	0	(0)	0	(0)	2	(0)	1	(0)	1	(1)	4	(2)	2	(0)	0	(0)	0	(0)	0	10	(3)
1994	25	0	(0)	0	(0)	0	(0)	2	(2)	0	(0)	1	(1)	0	(0)	0	(0)	0	(0)	0	3	(3)
1995	13	0	(0)	0	(0)	0	(0)	1	(1)	2	(2)	2	(1)	0	(0)	0	(0)	0	(0)	0	5	(4)
Mean	19.9	0.1	(0)	0.3	(0)	0.5	(0)	1.0	(1)	1.0	(1)	1.2	(1)	0.8	(0)	0.5	(0)	0.1	(0)	0.0	5.2	(3.1)
Total	957	4	(1)	12	(4)	20	(11)	42	(26)	46	(26)	55	(28)	30	(10)	19	(1)	4	(0)	0	250	(107)

Source : PAGASA

Figure in ( ) indicates number of tropical cyclones in case maximum daily rainfall is more than 50 mm.

- : Not available

Table B.2.2 (1/4) Rainfall caused by Tropical Cyclones in N. Luzon

No.	Year	Categories	Name	Date	Rainfall (mm)	
					1 day	2 days
1	1948	TD	-	-	-	-
2	1948	TY	GERTRUDE	-	-	-
3	1948	TY	KIT	-	-	-
4	1948	TD	-	-	-	-
5	1948	TY	-	-	-	-
6	1948	TY	-	-	-	-
7	1949	TY	-	-	-	-
8	1949	TY	OMELIA	Sept. 29 - Oct. 4	-	-
9	1949	TY	-	-	-	-
10	1949	TY	CAMILLA	Dec. 9 - 13	-	-
11	1950	TY	IDA	Aug. 9-12	-	-
12	1950	TY	OSSIA	Sept. 28 - Oct. 5	-	-
13	1950	TS	-	-	-	-
14	1951	TY	LOUISE	July 25 - Aug. 1	-	-
15	1951	TD	-	-	-	-
16	1951	TY	NORA	Aug. 27 - Sept. 2	-	-
17	1951	TY	ORA	Sept. 13 - Aug. 20	-	-
18	1951	TY	PAT	Sept. 22 - 26	-	-
19	1952	TY	DINAH	June 15 - 22	-	-
20	1952	TD	-	-	-	-
21	1952	TY	HARRIET	July 26 - 29	-	-
22	1952	TY	MARY	Aug. 29 - Sept. 20	-	-
23	1952	TY	NONA	Aug. 31 - Sept. 5	-	-
24	1952	TD	-	-	-	-
25	1952	TY	BESS	Nov. 9 - 14	-	-
26	1952	TY	DELLA	Nov. 21 - 27	-	-
27	1953	TY	JUDY	May 30 - June 6	-	-
28	1953	TS	-	-	-	-
29	1953	TY	OPHELIA	Aug. 1 - 13	-	-
30	1953	TY	RITA	Aug. 28 - Sept. 2	-	-
31	1953	TY	SUSAN	Sept. 12 - 19	-	-
32	1953	TY	CORA	Nov. 12 - 19	-	-
33	1954	TY	IDA	Aug. 24 - 29	-	-
34	1954	TY	MARIE	Sept. 19 - 25	-	-
35	1954	TY	NANCY	Oct. 20 - 30	-	-
36	1954	TS	PAMELA	Oct. 27 - Nov. 6	-	-
37	1954	TY	RUBY	Nov. 4 - 11	-	-
38	1954	TY	SALLY	Nov. 12 - 20	-	-
39	1955	TS	-		-	-
40	1955	TY	IRIS	Aug. 21 - 24	-	-
41	1955	TY	KATE	Sept. 18 - 24	-	-
42	1956	TY	THELMA	Apr. 17 - 24	-	-
43	1956	TD	-	-	-	-
44	1956	TS	-	-	-	-
45	1956	TY	CHARLOTTE	Aug. 26 - 30	-	-
46	1956	TY	GILDA	Sept. 17 - 23	-	-
47	1956	TY	JEAN	Oct. 15 - 24	-	-
48	1956	TY	LUCILLE	Nov. 12 - 20	-	-
49	1956	TD	MARY	Nov. 15 - 16	-	-
50	1956	TY	OLIVE	Nov. 25 - 29	-	-
51	1957	TY	VIRGINIA	June 20 - 26	-	-
52	1957	TD	-	-	-	-
53	1957	TY	WENDY	July 9 - 16	-	-
54	1957	TY	CARMEN	Sept. 7 - 15	-	-
55	1957	TY	GLORIA	Sept. 17 - 22	-	-
56	1957	TY	FAYE	Sept. 19 - 26	-	-
57	1957	TY	KIT	Nov. 8 - 17	-	-
58	1958	TY	BETTY	July 15 - 16	-	-
59	1958	TD	-	-	-	-
60	1959	TY	IRIS	Aug. 19 - 23	-	-
61	1959	TS	NORA	Sept. 5 - 12	-	-
62	1959	TY	FREDA	Nov. 12 - 19	-	-
63	1960	TY	KAREN	Apr. 19 - 26	-	-
64	1960	TS	LUCILLE	May 24 - 31	-	-
65	1960	TD	-	-	-	-
66	1960	TY	ELAINE	Aug. 19 - 25	-	-

Source: PAGASA

Note: TY: Typhoon, TS: Tropical Storm, TD: Tropical Depression, -: Not available

Table B.2.2 (2/4) Rainfall caused by Tropical Cyclones in N. Luzon

No.	Year	Categories	Name	Date	Rainfall (mm) 1 day	Rainfall (mm) 2 days
67	1960	TS	IRMA	Sept. 11 - 18	-	-
68	1960	TY	LOLA	Oct. 10 - 15	-	-
69	1961	TY	BETTY	May 21 - 25	36.1	50.6
70	1961	TD	-	July 10-14	494.8	670.8
71	1961	TS	FLOSSIE	July 16 - 19	137.2	191.0
72	1961	TY	JUNE	Aug. 1-9	149.1	152.4
73	1961	TD	-	Aug. 17-19	46.5	54.1
74	1961	TY	LORNA	Aug. 22 - 25	287.8	513.1
75	1961	TS	-	Aug. 27-30	33.5	47.0
76	1962	TY	HOPE	May 16 - 21	11.7	13.2
77	1962	TY	KATE	July 8 - 23	254.8	491.3
78	1962	TD	-	July 28-30	80.5	159.2
79	1962	TY	WANDA	Aug. 29 - 31	409.2	468.4
80	1963	TS	BEBENG	June 4 - 9	294.9	471.7
81	1963	TS	DIDING	June 25 - 29	43.9	48.7
82	1963	TY	ISING	July 18 - 21	172.0	204.0
83	1963	TY	LUDING	Aug. 3-10	10.2	18.8
84	1963	TY	NENENG	Sept. 1 - 6	245.6	330.9
85	1964	TY	SENIANG	Aug. 4 - 8	77.8	123.0
86	1964	TY	YONING	Sept. 1 - 4	162.9	196.9
87	1964	TY	ARING	Sept. 6 - 10	149.6	221.3
88	1964	TY	BASIANG	Sept. 16-20	36.3	59.1
89	1964	TY	DORANG	Oct. 2 - 6	33.1	38.1
90	1964	TY	EMANG	Oct. 7 - 13	48.9	56.3
91	1964	TD	ORING	Nov. 16-22	29.5	45.5
92	1965	TY	GORING	May 30 - June 2	72.1	125.4
93	1965	TY	HULING	June 14 - 19	90.9	120.9
94	1965	TS	LUMING	July 5 - 9	28.5	35.1
95	1965	TY	MILING	July 8 - 14	33.0	39.6
96	1965	TD	NARSING	July 16 - 20	212.1	212.9
97	1965	TY	UNDING	Aug. 31 - Sept. 4	280.6	304.5
98	1966	TD	BISING	May 2 - 4	44.1	84.7
99	1966	TY	KLARING	May 6 - 10	52.9	64.6
100	1966	TS	GADING	May 20 -22	21.1	30.5
101	1966	TD	HELING	June 28 - 20	19.1	36.1
102	1966	TS	ILIANG	Aug. 4 - 8	40.6	60.7
103	1966	TD	MIDING	Aug. 13 -16	96.6	179.4
104	1966	TD	NORMING	Aug. 20 23	86.2	165.5
105	1966	TY	OYANG	Sept. 2 - 6	136.2	229.2
106	1966	TS	TITANG	Sept. 10 -14	111.0	139.3
107	1966	TS	WENING	Sept. 19 - 24	31.5	44.9
108	1967	TY	KARING	Apr. 4 - 13	106.4	108.9
109	1967	TY	GENING	June 27 - 29	510.3	557.2
110	1967	TD	ONIANG	Aug. 11 - 15	52.3	103.9
111	1967	TS	PEPANG	Aug. 18 - 20	79.0	113.5
112	1967	TY	ROSING	Aug. 25 - 30	95.0	163.8
113	1967	TY	TRINING	Oct. 14 - 19	113.8	219.5
114	1968	TS	DIDANG	July 21 - 28	248.5	308.2
115	1968	TS	GLORING	Aug. 7 - 11	128.3	170.0
116	1968	TY	HUANING	Aug. 16 - 20	184.7	238.6
117	1968	TY	LUSING	Sept. 1 - 8	57.2	101.6
118	1968	TY	NITANG	Sept. 23 - Oct. 1	198.8	271.8
119	1968	TY	TOYANG	Nov. 26 - 29	0.0	0.0
120	1969	TY	ELANG	July 25 - 29	152.1	281.5
121	1969	TY	GORING	July 30 - Aug. 2	21.1	32.5
122	1969	TS	LUMING	Sept. 5 - 11	103.0	191.9
123	1969	TY	OPENG	Sept. 29 - Oct. 7	58.7	102.9
124	1970	TY	EMANG	Sept. 11 - 16	51.0	58.3
125	1970	TS	HELING	Aug. 4 - 10	44.4	56.1
126	1970	TY	PITANG	Sept. 1 - 7	78.5	135.7
127	1970	TD	RUPING	Sept. 21 - 25	42.1	58.6
128	1971	TS	ETANG	Apr. 28 - May 7	15.0	25.8
129	1971	TY	LUDING	June 11 - 18	41.7	49.3
130	1971	TY	ROSING	July 16 - 26	101.3	197.6
131	1971	TY	URING	Aug. 7 - 11	153.2	231.7
132	1971	TS	ADING	Sept. 5 - 10	100.4	156.8

Source: PAGASA

Note: TY: Typhoon, TS: Tropical Storm; TD: Tropical Depression; -: Not available

Table B.2.2 (3/4) Rainfall caused by Tropical Cyclones in N. Luzon

No.	Year	Categories	Name	Date	Rainfall (mm)	
					1 day	2 days
133	1971	TS	KRISING	Oct. 8 - 11	225.2	393.3
134	1972	TS	EDENG	July 15 - 18	249.7	368.0
135	1973	TD	ATRING	June 29 - July 2	32.6	37.9
136	1973	TD	KURING	July 14 - 18	105.7	129.3
137	1973	TS	HULING	Sept. 1 - 3	320.6	496.4
138	1973	TS	IBIANG	Sept. 6 - 10	17.8	34.8
139	1973	TY	LUMING	Oct. 2 - 10	137.1	269.9
140	1973	TY	MILING	Oct. 9 - 12	137.1	148.0
141	1974	TY	BISING	June 2 - 5	162.9	274.7
142	1974	TD	LOLENG	Aug. 6 - 10	77.0	107.2
143	1974	TS	RUPING	Sept. 24 - 29	113.6	226.7
144	1974	TY	SUSANG	Oct. 9 - 12	134.9	194.3
145	1974	TY	TERING	Oct. 14 - 17	5.0	8.4
146	1974	TY	UDING	Oct. 21 - 25	40.4	67.1
147	1974	TY	WENDING	Oct. 25 - 29	38.4	51.3
148	1974	TY	ANING	Nov. 4 - 8	51.7	93.8
149	1975	TY	HERMING	Sept. 16 - 18	0.0	0.0
150	1975	TY	MANENG	Oct. 9 - 13	67.2	67.2
151	1975	TS	NENENG	Oct. 12 - 19	64.1	79.4
152	1976	TY	DIDANG	May 24 - 27	128.4	219.1
153	1976	TY	HUANING	June 22 - July 2	77.8	20.2
154	1976	TS	PARING	Aug. 21 - 24	34.6	59.2
155	1977	TY	ELANG	July 16 - 19	3.9	3.9
156	1977	TY	GORING	July 23 - 25	239.9	305.7
157	1977	TD	NARSING	Sept. 11 - 12	20.1	28.7
158	1977	TY	OPENG	Sept. 14 - 22	96.8	159.8
159	1977	TS	PINING	Sept. 21 - 24	116.9	132.7
160	1978	TS	KLARING	June 21 - 24	157.0	202.4
161	1978	TS	RUPING	Sept. 3 - 9	15.5	31.0
162	1978	TD	SUSANG	Sept. 13 - 18	46.2	60.6
163	1979	TY	ETANG	July 1 - 4	104.7	135.2
164	1979	TS	HERMING	July 25 - 28	183.4	226.3
165	1979	TY	ISING	July 28 - Aug. 1	42.9	78.7
166	1979	TD	LUDING	Aug. 3 - 6	96.8	115.1
167	1979	TD	SISANG	Oct. 1 - 3	4.0	7.0
168	1979	TY	YAYANG	Nov. 3 - 7	10.7	17.3
169	1979	TS	KRISING	Dec. 21 - 23	6.0	6.0
170	1980	TY	DITANG	May 10 - 20	42.9	48.9
171	1980	TS	GLORING	May 23 - 26	21.6	26.6
172	1980	TY	LUSING	July 7 - 11	215.2	280.9
173	1980	TY	NITANG	July 16 - 19	68.2	106.5
174	1980	TY	OSANG	July 20 - 26	77.8	86.4
175	1980	TD	PARING	Aug. 23 - 26	31.2	55.5
176	1980	TY	ARING	Nov. 1 - 7	49.7	75.3
177	1981	TS	ELANG	June 11 - 14	113.6	173.6
178	1981	TY	RUBING	Sept. 15 - 20	111.0	172.6
179	1981	TY	ANDING	Nov. 21 - 27	16.2	18.2
180	1982	TS	EMANG	July 1 - 4	189.0	356.0
181	1982	TY	NORMING	Aug. 20 - Sept. 3	28.4	39.0
182	1982	TY	WELING	Oct. 11 - 15	22.0	35.0
183	1982	TS	BIDANG	Dec. 8 - 10	0.0	0.0
184	1983	TY	KARING	July 22 - 25	39.0	57.6
185	1983	TS	ETANG	Aug. 12 - 15	129.4	213.1
186	1983	TY	HERMING	Sept. 3 - 7	180.9	223.7
187	1983	TS	PEPANG	Oct. 9 - 15	6.2	7.5
188	1983	TS	SISANG	Oct. 20 - 22	1.0	1.0
189	1984	TY	BIRING	July 1 - 3	62.4	69.6
190	1984	TS	KONSING	July 17 - 18	42.2	51.0
191	1984	TD	EDENG	Aug. 11 - 15	46.6	85.5
192	1984	TS	MARING	Aug. 27 - 30	149.2	272.5
193	1984	TD	SENIANG	Oct. 25 - 26	0.0	0.0
194	1984	TY	WELPRING	Nov. 14 - 21	5.0	9.2
195	1985	TY	KURING	June 21 - 25	221.8	337.2
196	1985	TS	MILING	Sept. 1 - 4	23.2	34.0
197	1985	TS	NARSING	Sept. 15 - 17	6.2	6.2
198	1985	TD	OPENG	Sept. 24 - 26	6.8	10.0

Source: PAGASA

Note: TY: Typhoon, TS: Tropical Storm, TD: Tropical Depression, -: Not available

Table B.2.2 (4/4) Rainfall caused by Tropical Cyclones in N. Luzon

No.	Year	Categories	Name	Date	Rainfall (mm)	
					1 day	2 days
199	1985	TY	TASING	Oct. 23 - 30	125.6	241.2
200	1986	TS	KLARING	May 24 - 29	70.0	135.0
201	1986	TY	DELING	June 1 - 9	36.2	51.8
202	1986	TY	GADING	July 7 - 10	93.8	175.0
203	1986	TY	MIDING	Aug. 30 - Sept. 3	228.2	364.2
204	1986	TD	SUSANG	Oct. 30 - Nov. 1	9.2	18.0
205	1987	TY	ETANG	July 23 - 27	33.0	42.6
206	1987	TY	ISING	Aug. 12 - 20	85.4	104.6
207	1987	TY	NENENG	Sept. 4 - 9	111.0	156.1
208	1987	TY	PEPANG	Oct. 23 - 25	157.6	279.7
209	1988	TS	KONSING	June 1 - 13	139.7	169.9
210	1988	TY	HUANING	July 14 - 19	97.4	145.9
211	1988	TS	MARING	Sept. 19 - 20	131.5	136.7
212	1988	TY	TOYANG	Oct. 18 - 21	13.0	21.0
213	1988	TY	APIANG	Dec. 23 - 26	0.0	0.0
214	1989	TD	ELANG	July 6 - 11	23.0	24.6
215	1989	TY	GORING	July 11 - 18	86.2	134.0
216	1989	TY	RUBING	Sept. 29 - Oct. 8	64.9	120.3
217	1989	TY	TASING	Oct. 13 - 20	16.4	16.4
218	1989	TY	UNSING	Nov. 16 - 23	0.0	0.0
219	1989	TY	OPENG	Sept. 8 - 11	437.2	658.1
220	1990	TY	BISING	June 17 - 23	192.0	259.0
221	1990	TY	KLARING	June 22 - 29	192.0	275.2
222	1990	TY	HELING	Aug. 24 - 28	83.8	135.6
223	1990	TY	MIDING	Sept. 10 - 16	233.2	246.8
224	1990	TY	ILIANG	Aug. 29-31	224.4	372.6
225	1991	TY	GENING	July 16 - 20	164.1	320.7
226	1991	TY	LUDING	Aug. 13 - 15	140.4	141.7
227	1991	TY	ONIANG	Sept. 15 - Oct. 2	111.6	152.8
228	1991	TY	TRINING	Oct. 20 - 31	127.6	185.6
229	1991	TY	WARLING	Nov. 4 - 14	0.0	0.0
230	1992	TY	KONSING	July 9 - 12	3.8	4.2
231	1992	TD	DITANG	July 17 - 21	1.2	1.8
232	1992	TS	MARING	Sept. 19 - 22	265.0	450.4
233	1993	TD	ELANG	June 17 - 20	4.0	5.8
234	1993	TY	GORING	June 22 - 26	20.4	37.8
235	1993	TS	IBIANG	July 13 - 17	19.5	21.1
236	1993	TS	RUBING	Aug. 15 - Sept. 19	139.2	259.1
237	1993	TY	WALDING	Sept. 7 - 13	361.8	385.0
238	1993	TY	YEYENG	Sept. 12 - 16	361.8	378.6
239	1993	TY	ANDING	Sept. 17 - 20	1.8	1.8
240	1993	TY	KADIANG	Sept. 30 - Oct. 7	40.8	80.6
241	1993	TD	EPANG	Oct. 6 - 13	40.8	40.9
242	1993	TY	HUSING	Oct. 28 - Nov. 3	5.2	5.2
243	1994	TY	LOLENG	July 10 - 11	143.7	166.1
244	1994	TD	NORMING	July 17 - 21	175.9	242.5
245	1994	TD	WELING	Sept. 7 - 11	446.8	450.2
246	1995	TS	KARING	July 25 - 31	140.8	192.4
247	1995	TS	DIDING	Aug. 7 - 9	75.2	88.6
248	1995	TY	GENING	Aug. 25 - 31	224.2	402.2
249	1995	TS	HELMING	Sept. 2 - 5	29.4	33.0
250	1995	TY	LUDING	Sept. 21 - 23	63.7	81.9

Source: PAGASA

Note: TY: Typhoon; TS: Tropical Storm; TD: Tropical Depression; -: Not available

Table B.2.3 Mean Monthly Rainfall

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1961	0.0	0.0	2.3	0.0	101.0	529.5	1,306.9	933.7	352.7	0.0	0.0	0.0	3,226.1
1962	0.0	0.0	0.0	0.5	22.9	282.8	1,252.9	852.1	89.7	28.1	14.5	0.0	2,543.5
1963	0.6	0.0	0.5	0.0	10.7	1,134.5	369.5	76.2	628.0	6.4	8.9	43.7	2,279.0
1964	18.5	0.7	21.2	0.0	38.1	304.1	139.6	648.4	601.5	104.3	88.4	120.5	2,085.3
1965	0.0	0.0	0.0	4.6	267.6	585.3	395.4	208.1	393.6	7.5	45.2	2.0	1,909.3
1966	0.0	0.0	1.3	0.3	217.4	49.8	122.8	517.8	600.5	15.6	194.8	4.3	1,724.6
1967	0.0	0.0	0.0	121.9	210.5	1,082.7	231.3	727.1	233.6	229.3	36.1	0.0	2,872.5
1968	0.0	1.0	0.0	6.8	25.4	108.3	582.4	914.6	497.4	24.4	0	0.0	2,160.3
1969	9.4	2.8	4.9	0.0	215.8	327.6	733.7	328.7	1,007.3	115.6	12.8	0.8	2,759.4
1970	0.5	0.0	0.0	7.1	81.4	481.0	217.5	494.8	438.7	77.3	27.9	27.3	1,853.5
1971	0.0	6.2	0.0	0.0	37.2	148.2	269.7	344.8	590.1	495.5	27.0	65.1	1,983.8
1972	0.0	0.0	0.0	2.8	94.3	324.0	1,457.6	303.6	40.2	0.3	0.5	0.0	2,223.3
1973	0.0	0.0	0.0	12.7	22.2	164.3	319.7	218.2	564.7	376.5	49.2	0.0	1,727.5
1974	0.0	0.0	0.0	28.5	125.4	394.3	25.5	988.7	454.0	344.2	118.3	4.5	2,483.4
1975	23.1	0.0	0.0	12.2	55.7	375.4	63.0	812.9	65.6	132.6	0.0	5.7	1,546.2
1976	0.0	0.0	0.0	3.3	261.3	283.9	211.1	173.3	154.7	63.4	11.8	0.0	1,162.8
1977	9.6	0.0	0.0	20.4	33.2	189.0	455.8	627.6	621.8	0.0	86.0	0.0	2,043.4
1978	0.0	0.0	0.0	51.6	119.0	429.2	227.8	443.7	259.1	107.2	41.5	0.0	1,679.1
1979	0.0	0.0	0.0	15.9	420.7	95.0	525.6	483.4	114.4	79.6	17.3	6.0	1,757.9
1980	38.8	0.0	0.0	0.0	89.5	80.2	579.5	124.9	475.9	110.2	79.3	0.0	1,578.3
1981	0.5	0.0	0.0	0.2	230.6	507.2	205.9	508.3	235.3	93.7	31.6	0.0	1,813.3
1982	0.0	0.0	0.0	0.8	67.8	345.8	772.5	630.2	160.3	36.8	28.2	15.6	2,058.0
1983	0.3	12.2	26.0	2.2	27.7	249.0	196.6	664.1	353.4	80.6	0.0	4.0	1,616.1
1984	0.0	0.0	0.0	285.2	178.2	248.7	197.4	716.3	60.4	14.3	10.8	0.0	1,711.3
1985	0.0	0.0	0.0	0.0	184.0	1,069.5	41.3	1,015.4	134.9	327.4	23.8	2.2	2,798.5
1986	16.5	0.1	0.0	0.0	540.6	88.0	355.9	1,146.1	514.7	57.7	59.7	0.0	2,779.3
1987	0.0	0.0	0.0	1.0	0.0	250.6	263.8	291.2	243.8	315.1	0.2	3.1	1,368.8
1988	5.3	0.2	0.0	8.0	171.0	293.3	554.6	266.2	238.9	62.3	1.1	0.0	1,600.9
1989	0.0	0.2	2.0	0.0	80.7	160.7	446.0	494.1	1,152.6	136.9	0.0	0.6	2,473.8
1990	8.6	0.0	0.0	17.6	389.0	554.5	320.7	1,029.1	540.0	29.6	1.9	0.2	2,891.2
1991	0.0	0.0	0.0	0.0	3.3	163.8	734.1	511.8	402.6	247.3	0.0	0.0	2,062.9
1992	7.2	9.0	0.0	50.9	405.3	305.3	53.8	751.9	656.8	28.8	0.4	0.0	2,269.4
1993	0.0	0.0	2.7	0.0	83.8	76.3	332.3	393.0	443.4	124.5	10.4	8.2	1,474.6
1994	3.7	18.0	0.0	48.4	262.3	291.3	943.8	660.9	604.4	101.3	0.0	0.0	2,934.1
1995	0.0	0.0	0.0	0.0	327.5	450.5	597.3	986.7	466.3	286.6	141.5	0.0	3,256.4
Mean	4.1	1.4	1.7	20.1	154.3	355.0	443.0	579.7	411.2	121.7	34.4	9.0	2,134.5

Source : PAGASA

Table B.2.4 Monthly Temperature

(Unit : °C)

Year	Jan Max.	Jan Ave.	Jan Min.	Feb. Max.	Feb. Ave.	Feb. Min.	Mar. Max.	Mar. Ave.	Mar. Min.	Apr. Max.	Apr. Ave.	Apr. Min.	May. Max.	May. Ave.	May. Min.	Jun. Max.	Jun. Ave.	Jun. Min.
1961	28.9	23.0	17.1	29.9	24.3	18.7	31.6	26.4	21.2	32.9	28.1	23.2	33.1	28.8	24.6	31.6	27.8	24.0
1962	29.1	23.9	18.8	30.3	23.7	17.0	31.3	26.4	21.6	32.5	27.8	23.1	33.5	29.0	24.5	32.5	28.3	24.2
1963	27.3	22.5	17.8	30.0	23.7	17.5	30.3	24.7	19.1	31.8	26.5	21.1	33.6	28.8	24.0	30.7	27.2	23.6
1964	30.8	24.9	18.9	30.8	25.2	19.7	31.3	26.1	20.8	32.8	27.8	22.9	33.7	29.1	24.5	31.8	27.9	24.0
1965	28.6	23.8	19.1	30.5	24.5	18.6	31.0	25.6	20.1	32.6	27.6	22.6	32.8	28.4	24.0	30.8	27.3	23.8
1966	30.5	24.7	18.8	31.4	25.8	20.1	32.1	26.6	21.0	33.1	28.2	23.3	32.4	28.4	24.4	32.7	28.4	24.1
1967	30.2	24.3	18.4	30.4	24.3	18.1	30.9	25.4	19.9	31.7	27.3	22.8	33.2	28.4	23.5	30.9	27.1	23.4
1968	29.9	23.7	17.6	29.5	23.3	17.1	31.0	25.6	20.2	32.9	27.1	21.3	33.6	28.5	23.5	33.2	28.7	24.2
1969	30.3	24.7	19.2	29.9	24.4	18.8	31.9	26.7	21.4	33.1	28.1	23.0	34.2	29.2	24.2	32.2	28.5	24.8
1970	30.1	24.6	19.1	31.1	24.7	18.2	32.5	27.0	21.4	33.8	28.6	23.3	34.5	29.5	24.5	33.1	28.7	24.3
1971	29.2	23.2	17.1	31.1	25.0	19.0	32.3	25.7	19.2	33.2	27.4	21.6	34.3	28.9	23.4	32.6	28.1	23.6
1972	29.9	24.7	19.5	31.4	25.0	18.6	32.1	25.7	19.2	34.8	28.4	22.1	35.0	29.5	24.0	33.6	28.9	24.3
1973	31.3	25.0	18.7	32.8	26.2	19.5	33.9	26.8	19.7	34.6	29.0	23.3	35.7	30.0	24.2	33.8	29.0	24.1
1974	30.3	23.3	16.2	30.3	24.8	19.2	31.6	25.6	19.6	32.9	27.8	22.8	34.0	28.9	23.8	31.6	27.8	24.0
1975	30.8	25.3	19.8	31.3	25.3	19.3	32.7	26.7	20.6	35.0	29.0	23.0	35.8	30.1	24.4	33.1	28.6	24.2
1976	30.6	24.6	18.5	31.6	24.7	17.9	33.4	27.3	21.1	34.7	28.5	22.3	33.5	28.7	24.0	33.0	28.3	23.6
1977	31.2	25.7	20.1	31.4	25.0	18.5	33.0	26.4	19.7	35.5	29.2	22.8	36.2	30.4	24.5	35.6	30.0	24.5
1978	30.3	23.9	17.6	31.0	24.8	18.6	33.2	27.0	20.9	34.6	28.6	22.6	35.2	29.6	23.9	32.8	28.6	24.3
1979	30.7	24.2	17.6	31.0	25.4	19.9	32.7	26.8	20.9	34.2	29.2	24.2	32.6	28.5	24.5	33.7	29.2	24.8
1980	29.5	24.8	20.1	31.2	25.5	19.8	32.7	27.6	22.4	33.8	28.9	24.0	33.1	29.0	24.9	34.5	29.8	25.1
1981	30.1	24.4	18.6	31.8	25.6	19.3	32.4	26.7	21.1	34.3	29.1	23.9	33.7	29.3	24.9	31.6	28.0	24.5
1982	30.0	24.0	17.9	30.2	24.8	19.4	32.0	26.8	21.6	33.1	28.5	23.8	33.4	29.1	24.8	32.6	28.8	24.9
1983	29.9	25.6	21.3	30.2	24.9	19.6	31.5	26.7	21.9	32.8	27.9	23.1	34.0	29.5	25.0	33.7	29.5	25.3
1984	29.2	24.5	19.7	30.4	25.3	20.2	32.1	27.3	22.5	32.9	28.4	23.9	31.9	28.1	24.4	32.1	28.3	24.5
1985	30.0	24.0	18.1	31.1	26.3	21.5	32.6	27.5	22.4	33.4	28.9	24.5	33.7	29.2	24.6	30.5	27.3	24.1
1986	29.6	24.4	19.1	29.7	24.9	20.2	31.1	26.4	21.7	32.4	28.1	23.7	31.5	28.0	24.4	31.8	28.1	24.4
1987	30.6	24.1	17.7	30.5	23.9	17.3	32.2	26.3	20.5	34.1	28.2	22.3	35.0	29.1	23.3	33.4	29.1	24.8
1988	31.8	26.2	20.6	32.6	26.9	21.2	33.0	27.3	21.7	34.8	29.2	23.5	34.9	29.7	24.6	32.8	28.5	24.2
1989	32.5	25.8	19.1	32.0	25.8	19.6	32.4	26.6	20.9	33.7	28.2	22.6	33.8	29.1	24.4	33.1	28.7	24.3
1990	31.1	24.9	18.6	31.6	25.8	20.0	32.5	26.6	20.7	34.0	28.6	23.3	33.6	28.9	24.2	32.2	28.4	24.5
1991	31.2	25.2	19.2	32.0	26.2	20.3	33.2	27.0	20.8	34.3	28.7	23.0	35.3	29.8	24.4	34.2	29.5	24.7
1992	29.1	23.8	18.4	31.0	24.7	18.4	32.3	26.4	20.5	33.4	28.0	22.5	33.5	28.5	23.4	33.3	28.7	24.1
1993	30.0	24.3	18.6	31.5	25.1	18.6	32.6	26.2	19.9	34.0	28.2	22.3	34.7	29.3	23.8	34.6	29.5	24.4
1994	31.4	25.3	19.3	32.1	25.9	19.7	33.3	26.9	20.5	33.9	28.3	22.7	34.6	29.5	24.4	32.8	28.2	23.7
1995	30.9	24.9	18.8	30.4	24.6	18.7	32.4	26.6	20.7	34.6	28.6	22.7	33.5	28.8	24.1	34.0	29.2	24.5
Mean	30.2	24.5	18.7	31.0	25.0	19.1	32.2	26.5	20.8	33.6	28.3	22.9	33.9	29.1	24.2	32.8	28.5	24.3

Year	Jul. Max.	Jul. Ave.	Jul. Min.	Aug. Max.	Aug. Ave.	Aug. Min.	Sep. Max.	Sep. Ave.	Sep. Min.	Oct. Max.	Oct. Ave.	Oct. Min.	Nov. Max.	Nov. Ave.	Nov. Min.	Dec. Max.	Dec. Ave.	Dec. Min.	Annual Max.	Annual Ave.	Annual Min.
1961	29.4	26.3	23.1	30.1	26.8	23.6	29.9	26.6	23.3	-	-	-	-	-	-	-	-	-	30.8	26.5	22.1
1962	30.3	27.1	23.8	30.9	27.2	23.6	31.3	27.5	23.6	31.3	27.3	23.4	31.5	26.7	21.9	30.3	24.4	18.4	31.2	26.6	22.0
1963	30.7	27.1	23.6	31.9	28.1	24.3	31.0	27.5	24.0	32.1	27.0	21.8	32.5	26.6	20.8	30.3	26.0	21.7	31.0	26.3	21.6
1964	31.9	27.8	23.6	30.3	27.1	23.8	30.8	27.3	23.8	31.5	27.5	23.4	29.1	26.2	23.2	28.8	24.3	19.8	31.1	26.8	22.4
1965	30.8	27.3	23.8	31.3	27.5	23.8	31.3	27.2	23.2	32.4	27.0	21.7	32.1	27.0	21.8	31.6	25.3	19.0	31.3	26.5	21.8
1966	31.9	28.0	24.2	31.1	27.6	24.2	30.2	26.6	23.0	32.4	27.2	22.1	30.6	26.8	23.0	30.3	26.0	21.7	31.6	27.0	22.5
1967	31.4	27.8	24.2	30.3	27.1	23.8	30.9	27.0	23.1	30.4	26.3	22.1	31.0	26.1	21.2	28.8	23.9	19.1	30.8	26.3	21.6
1968	32.0	28.1	24.3	30.0	26.9	23.8	30.7	27.3	23.8	31.6	26.5	21.4	32.0	25.6	19.1	30.7	24.3	17.9	31.4	26.3	21.2
1969	31.7	27.9	24.0	31.7	27.6	23.5	30.9	27.3	23.7	31.6	27.0	22.4	30.4	26.3	22.2	31.2	25.7	20.3	31.6	27.0	22.3
1970	32.2	28.2	24.2	31.0	27.4	23.7	30.8	27.1	23.3	31.6	27.6	23.5	31.6	27.2	22.9	31.6	26.5	21.4	32.0	27.3	22.5
1971	31.6	27.6	23.5	31.5	27.2	22.9	31.5	27.3	23.2	30.9	27.0	23.0	30.1	26.0	21.9	30.5	25.9	21.3	31.6	26.6	21.6
1972	30.3	27.1	23.9	31.1	27.3	23.4	33.2	28.3	23.4	34.5	28.1	21.6	34.6	28.4	22.2	32.1	25.9	19.8	32.7	27.3	21.8
1973	32.3	27.9	23.6	31.4	27.4	23.3	32.8	28.0	23.3	32.0	27.6	23.2	31.3	26.9	22.5	30.2	25.1	19.9	32.7	27.4	22.1
1974	33.4	28.5	23.5	30.5	27.1	23.8	31.5	27.3	23.1	31.1	27.3	23.6	30.2	26.5	22.8	30.8	26.0	21.2	31.5	26.7	22.0
1975	33.4	28.5	23.5	30.2	27.0	23.8	33.7	28.4	23.2	32.8	28.1	23.4	32.6	26.4	20.3	30.8	25.7	20.7	32.7	27.4	22.2
1976	32.7	28.1	23.4	30.1	27.5	22.8	33.1	27.8	22.5	33.7	27.9	22.0	30.6	25.9	21.2	31.6	26.0	20.4	32.4	27.1	21.6
1977	32.5	28.1	23.7	31.6	27.8	23.9	31.0	27.3	23.5	33.1	27.8	22.5	31.1	26.4	21.8	31.4	25.2	18.9	32.8	27.4	22.0
1978	33.3	28.5	23.7	31.5	27.9	24.3	31.4	27.6	23.8	32.0	28.0	24.0	31.2	26.4	21.5	31.2	26.7	22.1	32.3	27.3	22.3
1979	32.5	28.5	24.6	30.7	27.4	24.2	32.6	28.2	23.8	31.3	27.0	22.7	30.9	27.0	23.1	30.0	24.9	19.8	31.9	27.2	22.5
1980	32.0	28.2	24.6	32.5	28.4	24.3	30.9	27.4	24.0	32.2	27.9	23.5	30.9	27.1	23.2	30.4	25.6	20.8	32.0	27.5	23.1
1981	32.2	28.3	24.3	31.5	27.9	24.3	32.4	28.4	24.3	32.4	28.0	23.6	31.4	27.4	23.3	29.8	25.0	20.2	32.0	27.3	22.7
1982	31.3	28.0	24.7	30.6	27.5	24.3	31.5	27.9	24.2	32.3	27.4	22.4	32.3	27.4	22.4	29.6	25.6	21.7	31.6	27.2	22.7
1983	33.2	29.3	25.1	31.2	27.7	24.2	32.5	28.3	24.1	32.3	28.3	24.3	30.0	25.9	21.8	30.2	24.4	18.5	31.8	27.3	22.9
1984	31.8	28.0	24.2	30.0	27.0	24.1	32.3	28.1	23.9	32.4	28.1	23.9	31.5	26.9	22.4	30.2	24.9	19.6	31.4	27.1	22.8
1985	31.7	28.1	24.6	30.1	27.2	24.3	32.5	27.8	24.1	30.7	27.2	23.7	31.5	26.9	22.4	29.4	25.1	20.7	31.4	27.1	22.9
1986	32.1	28.3	24.5	30.3	27.2	24.2	30.7	27.2	23.7	31.7	27.6	23.4	30.7	26.9	23.1	30.4	24.8	19.2	31.0	26.8	22.6
1987	32.5	28.2	24.0	32.2	28.6	24.0	32.3	27.7	23.2	32.1	27.3	22.5	32.6	27.5	22.4	31.2	26.2	21.1	32.4	27.2	21.9
1988	32.3	28.2	24.1	32.4	27.9	23.4	32.6	28.1	23.7	32.2	28.0	23.9	31.5	26.6	21.7	30.1	24.1	18.1	32.6	27.6	22.6
1989	32.6	28.3	24.0	31.9	27.8	23.6	31.3	27.1	23.0	32.4	27.4	22.3	31.7	26.6	21.5	30.3	24.2	18.1	32.3	27.1	22.0
1990	32.2	28.0	23.8	31.8	28.0	24.2	31.7	27.5	23.3	32.3	27.6	22.9	32.4	27.5	22.5	32.2	26.6	20.9	32.3	27.4	22.4
1991	32.1	28.0	23.8	32.0	27.9	23.8	31.3	27.4	23.4	31.2	26.6	22.0	-	-	-	31.4	24.6	17.9	32.6	27.4	22.1
1992	32.8	28.1	23.5	31.7	27.6	23.6	31.0	27.3	23.6	32.0	27.6	23.1	31.3	25.9	20.4	31.9	25.9	19.9	31.9	26.9	21.8
1993	33.2	28.6	24.0	32.5	28.1	23.8	31.9	27.6	23.4	31.7	27.2	22.7	32.9	27.2	21.5	31.1	26.5	21.8	32.6	27.3	22.1
1994	31.3	27.3	23.4	-	-	-	32.4	27.6	22.7	31.9	26.8	21.7	32.9	26.5	20.2	32.5	26.2	20.9	32.6	27.1	21.7
1995	32.6	28.2	23.8	32.3	28.1	23.9	32.7	28.4	24.0	32.8	28.3	23.7	31.8	27.2	22.1	30.6	25.6	20.5	32.4	27.4	22.3
Mean	32.0	28.0	24.0	31.2	27.6	23.8	31.7	27.6	23.5	32.0	27.5	22.9	31.5	26.7	21.9	30.7	25.4	20.1	31.9	27.0	22.2

Source: PAGASA

- : Not available

Table B.2.5 Mean Monthly Humidity

(Unit: %)

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1961	68.0	75.0	73.0	72.0	77.0	83.0	89.0	88.0	87.0	-	-	-	79.1
1962	70.0	67.0	77.0	71.0	78.0	85.0	88.0	87.0	85.0	77.0	73.0	68.0	77.2
1963	66.0	64.0	70.0	70.0	73.0	83.0	84.0	83.0	88.0	72.0	74.0	76.0	75.3
1964	73.0	69.0	70.0	73.0	74.0	81.0	82.0	86.0	86.0	80.0	79.0	77.0	77.5
1965	70.0	73.0	70.0	73.0	76.0	85.0	84.0	85.0	83.0	73.0	76.0	71.0	76.6
1966	75.0	73.0	72.0	73.0	78.0	79.0	83.0	85.0	85.0	75.0	84.0	80.0	78.5
1967	71.0	68.0	73.0	77.0	76.0	85.0	83.0	88.0	86.0	81.0	75.0	72.0	77.9
1968	72.0	72.0	74.0	70.0	73.0	77.0	83.0	87.0	86.0	72.0	66.0	75.0	75.6
1969	78.0	78.0	75.0	73.0	74.0	82.0	85.0	84.0	87.0	80.0	73.0	72.0	78.4
1970	74.0	73.0	72.0	72.0	74.0	81.0	82.0	87.0	88.0	84.0	79.0	78.0	78.7
1971	73.0	71.0	67.0	72.0	75.0	83.0	84.0	84.0	87.0	81.0	77.0	75.0	77.4
1972	75.0	75.0	68.0	69.0	75.0	79.0	90.0	85.0	82.0	74.0	70.0	74.0	76.3
1973	74.0	73.0	69.0	71.0	71.0	80.0	85.0	87.0	85.0	81.0	79.0	70.0	77.1
1974	69.0	72.0	73.0	75.0	72.0	82.0	77.0	87.0	84.0	85.0	80.0	78.0	77.8
1975	74.0	73.0	73.0	69.0	72.0	82.0	80.0	89.0	82.0	82.0	74.0	73.0	76.9
1976	68.0	73.0	72.0	72.0	77.0	81.0	84.0	86.0	85.0	80.0	74.0	74.0	77.2
1977	76.0	70.0	75.0	74.0	74.0	79.0	85.0	87.0	88.0	76.0	75.0	75.0	77.8
1978	70.0	71.0	72.0	72.0	74.0	80.0	81.0	87.0	84.0	78.0	71.0	70.0	75.8
1979	70.0	71.0	70.0	70.0	78.0	78.0	82.0	86.0	80.0	75.0	74.0	68.0	75.2
1980	74.0	71.0	71.0	70.0	81.0	79.0	84.0	85.0	87.0	78.0	78.0	69.0	77.3
1981	65.0	69.0	70.0	70.0	75.0	84.0	81.0	83.0	80.0	77.0	71.0	68.0	74.4
1982	70.0	74.0	74.0	72.0	75.0	81.0	85.0	86.0	85.0	80.0	78.0	80.0	78.3
1983	77.0	81.0	78.0	78.0	75.0	79.0	81.0	87.0	86.0	85.0	76.0	75.0	79.8
1984	78.0	77.0	76.0	76.0	82.0	84.0	83.0	87.0	82.0	76.0	77.0	72.0	79.2
1985	72.0	78.0	73.0	70.0	74.0	87.0	81.0	89.0	83.0	82.0	76.0	82.0	78.9
1986	75.0	76.0	76.0	77.0	84.0	86.0	86.0	91.0	90.0	84.0	84.0	78.0	82.3
1987	74.0	76.0	79.0	75.0	70.0	83.0	85.0	85.0	86.0	84.0	82.0	76.0	79.6
1988	81.0	77.0	79.0	74.0	77.0	84.0	89.0	87.0	88.0	83.0	76.0	73.0	80.7
1989	75.0	73.0	75.0	76.0	89.0	83.0	86.0	87.0	89.0	80.0	75.0	75.0	80.3
1990	78.0	80.0	74.0	76.0	80.0	87.0	88.0	88.0	87.0	82.0	79.0	75.0	81.2
1991	77.0	73.0	75.0	74.0	72.0	79.0	87.0	88.0	90.0	84.0	-	75.0	79.5
1992	79.0	78.0	80.0	79.0	81.0	83.0	85.0	88.0	89.0	80.0	76.0	79.0	81.4
1993	78.0	75.0	74.0	76.0	77.0	80.0	85.0	86.0	88.0	83.0	78.0	74.0	79.5
1994	76.0	77.0	70.0	77.0	78.0	85.0	89.0	-	84.0	78.0	73.0	73.0	78.2
1995	74.4	76.5	76.9	76.1	80.5	80.8	85.9	88.5	88.5	82.2	79.1	72.3	80.1
Mean	73.4	73.5	73.3	73.3	76.3	82.0	84.3	86.6	85.7	79.5	76.1	74.2	78.2

Source: PAGASA

- : Not available

Table B.2.6 Mean Monthly Wind Speed and Direction

(Unit : m/s)

Year	Jan.		Feb.		Mar.		Apr.		May.		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Annual	
1961	5	N	3	NW	3	NW	3	NW	3	SW	3	SW	4	S	4	SW	4	SW	-	-	-	-	-	-	4	SW
1962	5	N	4	NW	4	NW	3	NW	3	E	3	SW	4	SW	3	S	3	E	4	N	4	N	4	N	4	N
1963	5	N	4	N	3	NW	4	NW	4	W	4	SW	3	SW	3	SW	4	SW	4	NNE	3	NW	4	N	4	SW
1964	6	N	8	E	6	NNW	6	NW	6	NW	6	SW	5	SW	4	SW	3	NW	3	N	5	N	4	N	5	N
1965	4	N	2	NW	3	NW	3	NW	3	E	3	SW	3	SW	3	SW	3	E	3	E	3	E	3	E	3	E
1966	2	E	3	E	2	E	5	E	3	WSW	3	E	2	E	3	E	3	SSW	3	E	3	NNE	3	NNE	3	E
1967	4	NNE	4	E	3	WNW	3	WNW	3	E	4	SSW	3	SW	3	SSW	3	E	4	N	3	N	4	N	3	E
1968	3	N	4	N	3	NW	3	WNW	4	WNW	3	E	4	E	3	S	4	NE	3	NNE	3	E	2	N	3	E
1969	3	N	3	N	3	WNW	3	W	2	N	3	W	3	W	2	S	3	W	2	N	4	N	4	N	3	N
1970	3	N	2	N	3	NW	2	N	2	W	2	W	3	SW	2	W	2	S	1	E	2	N	3	N	2	N
1971	3	N	3	NE	3	N	3	N	2	NW	4	WSW	3	SW	3	SW	2	SW	3	NNE	3	NNE	6	N	3	N
1972	3	N	2	NNW	3	NW	2	NW	2	W	2	SW	4	S	2	S	2	E	2	.E	3	E	3	N	3	E
1973	2	NW	2	W	2	W	2	NW	2	W	2	SW	3	E	2	E	2	E	3	NNE	6	N	6	NNE	3	E
1974	4	NNE	5	N	4	N	3	WSW	3	WNW	3	SSW	2	E	3	S	3	E	4	ENE	5	N	4	N	4	N
1975	6	NNE	3	ENE	3	NW	3	WNW	2	ENE	2	SW	2	E	3	S	2	E	3	E	3	N	4	N	3	E
1976	3	N	2	E	3	N	2	NW	4	E	3	E	3	E	3	E	2	E	2	E	5	N	3	N	3	E
1977	3	N	4	N	2	WNW	2	WNW	2	SW	2	SW	3	SW	3	SW	3	E	3	N	4	N	3	E	3	SW
1978	5	N	3	N	2	W	2	NW	2	SW	3	SW	3	S	3	S	2	E	3	N	4	N	3	N	3	N
1979	2	W	3	W	2	W	2	W	3	W	2	E	3	W	3	S	3	E	4	N	4	N	4	N	3	W
1980	4	N	4	N	3	W	3	W	3	W	3	E	4	S	3	E	3	E	3	E	4	N	4	N	3	E
1981	4	E	3	NNW	3	W	3	W	2	W	3	E	3	E	3	S	3	E	3	E	4	N	4	N	3	E
1982	3	E	3	E	2	E	3	NNW	3	E	3	E	3	W	3	S	3	E	3	E	3	E	3	N	3	E
1983	4	N	2	E	2	W	2	W	3	W	3	E	2	E	3	E	2	E	2	E	4	N	3	N	3	E
1984	3	N	3	N	3	W	3	WNW	2	E	3	E	2	E	4	S	2	E	3	N	3	N	4	N	3	N
1985	3	N	2	NW	3	NNW	3	NNW	3	E	4	S	3	E	3	S	2	E	3	W	3	N	3	N	3	E
1986	3	NNE	3	N	3	NNW	2	W	3	S	3	SW	3	S	3	S	3	E	3	N	4	N	3	N	3	N
1987	3	N	3	W	2	W	3	W	3	W	3	SW	3	SW	3	E	2	W	3	E	3	E	4	N	3	W
1988	3	N	3	N	3	W	3	W	3	SW	3	W	3	S	3	E	2	E	3	NNE	4	N	3	N	3	N
1989	3	E	3	N	3	NNW	2	W	2	W	2	E	3	SW	3	SW	3	SW	3	NNE	4	N	3	E	3	E
1990	3	N	2	W	2	NNW	2	W	2	W	2	E	2	SW	3	WSW	2	NW	2	N	3	NNE	3	N	2	W
1991	2	N	3	NNE	2	WNW	3	W	2	WNW	3	W	2	S	2	SW	2	S	3	W	1		3	E	2	W
1992	3	N	2	N	2	W	2	W	2	W	2	W	2	ESE	3	SW	3	SW	4	NNE	4	N	2	E	3	W
1993	3	N	2	NNW	2	W	2	NNW	2	W	2	W	2	SW	2	S	2	E	3	E	2	N	4	N	2	W
1994	3	N	3	E	3	N	2	W	2	E	2	E	2	S	3	S	2	E	3	NNE	3	E	2	E	3	E
1995	3	N	3	N	2	NW	2	W	2	E	2	SW	2	E	2	E	2	E	2	N	3	E	3	NE	2	E
Mean	3	N	3	N	3	W	3	W	3	W	3	SW	3	SW	3	S	3	E	3	E	4	N	3	N	3	E

Source: PAGASA

Note -: Not available; N:North; W:West; S: South; E:East

Table B.2.7 Mean Monthly Evaporation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1976	173.4	154.0	196.5	226.3	200.4	141.2	144.4	124.3	117.0	140.8	144.8	133.1	1896.2
1977	156.5	175.8	183.3	190.7	194.9	191.1	125.9	117.2	-	157.2	146.1	130.7	-
1978	147.4	154.4	169.7	157.9	176.6	129.2	154.8	102.8	136.9	135.8	128.9	129.9	1724.3
1979	131.0	125.8	166.6	159.7	150.6	147.4	126.4	109.8	115.8	123.2	124.9	120.3	1601.5
1980	125.5	126.3	162.4	191.9	148.9	146.2	127.7	137.8	102.6	114.1	99.5	126.8	1609.7
1981	135.9	144.2	167.5	192.6	156.7	-	121.5	118.8	124.9	112.6	116.0	136.2	1526.9
1982	136.9	130.3	152.5	183.0	159.3	137.7	-	-	102.9	128.4	-	-	-
1983	-	-	152.9	162.3	186.8	169.3	129.7	-	117.9	-	126.6	116.9	-
1984	139.0	141.7	175.5	162.2	148.8	126.0	151.5	-	125.8	125.3	108.3	133.9	-
1985	127.2	133.0	173.4	191.8	186.5	-	119.7	-	116.3	118.4	122.9	132.9	-
1986	143.1	139.1	171.7	173.9	137.2	141.1	142.0	-	107.4	141.6	124.5	131.7	-
1987	164.0	106.2	181.9	189.7	241.2	160.7	180.7	157.9	144.2	152.7	140.7	148.4	1968.3
1988	143.4	164.5	218.7	225.3	228.7	169.5	138.0	157.8	124.7	139.3	161.4	157.4	2028.7
1989	169.0	162.3	193.7	221.6	197.4	153.6	140.0	133.4	111.1	143.7	154.0	141.6	1921.4
1990	154.5	161.4	207.6	217.7	169.7	121.1	120.2	113.1	129.2	139.8	149.8	171.7	1855.8
1991	150.7	123.5	173.2	199.2	231.1	156.4	114.6	-	-	140.2	121.6	135.0	-
1992	129.4	151.2	181.8	177.3	130.3	168.4	150.6	108.7	111.5	131.1	131.8	132.0	1704.1
1993	146.3	161.6	185.2	195.2	190.2	166.5	153.2	139.0	122.5	123.8	135.5	158.6	1877.6
1994	135.8	147.7	207.9	181.9	181.1	127.1	-	140.8	139.8	127.8	132.5	122.5	-
1995	121.3	113.5	116.4	131.7	-	129.5	126.8	110.1	112.1	119.8	111.9	120.9	-
Mean	143.7	143.0	176.9	186.6	179.8	149.0	137.1	126.5	120.1	132.4	130.6	135.8	1761.6

Source :PAGASA

- : Not available

Table B.3.1 Inventory of Daily Rainfall Data

No.	Station Name	Elevation	Year																																		
			61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
	PAGASA																																				
1	Laoag	5 m	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
2	Batac	17 m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	NIA																																				
1	Labugaon Dam	115 m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B	B	B	B	B	B	B	B	B	B
2	Solsona Dam	113 m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B	B	B	B	B	B	B	B	B	B
3	Madongan Dam	128 m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B	B	B	B	B	B	B	B	B
4	Papa Dam	140 m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B	B	B	B	B	B	B	B	B	B	B
5	Nueva Era Dam	110 m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B	B	B	B	B	B	B	B	B	B	B	B
6	Manalpac	80 m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B	B	B	B	B	B	B	B	-	-	-	-	-	-	-	-	-	-	-	-
7	Lumbad	25 m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B	A	A	A	A	A	B	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Alabaan	40 m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B	B	B	-	-	-	-	-	-	-	-	-	-	-	-
9	Quiom	110 m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B	B	B	-	B	A	B	B	-	-	-	-	-	-	-	-	-	-	-	-
10	Paoay	25 m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B	B	B	B	-	-	-	-	-	-	-	-	-	-	-	-

A : Complete data ; B : Incomplete data ; - :Not available

Table B.3.2 Inventory of Daily Water Level and Discharge Data

No.	River	Location	Year																																						
			57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
	DPWH																																								
1	Laoag R.	Gilbert Br.	-	-	W	W	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	-	-	-	-	-	-	W	W	D	W	W	W	W	W	W	W	W	W
2	Bongo R.	Cauplasan Br.	W	W	W	W	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	-	D	-	-	-	W	W	W	W	W	W	W	W	W	W	W	-
3	Solsona R.	Solsona Dam	D	D	D	D	D	D	D	D	D	D	D	W	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	W	W	W	W	W	W	W	W	W	W	W

- : Not available D : Water level & Discharge ; W : Water level only ; Some data are missing ; Periodically observed at 7:00 - 8:00, 12:00 and 17:00 - 18:00

Table B.3.3 Inventory of Average Monthly Discharge

No.	River	Location	Year																	
			78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
	NIA																			
1	Labugaon R.	Labugaon Dam	-	-	-	-	-	B	B	-	-	B	A	A	A	A	A	B	B	-
2	Solsona R.	Solsona Dam	B	A	A	B	-	-	-	-	-	-	B	B	A	A	A	B	-	-
3	Madongan R.	Madongan Dam	-	-	-	-	-	A	B	-	-	-	A	A	A	A	A	B	-	-
4	Papa R.	Papa Dam	-	-	-	-	-	A	A	-	-	-	A	A	A	B	A	B	B	-
5	Bongo R.	Nueva Era Dam	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A	B	-

A : Complete data ; B : Incomplete data ; - :Not available

Table B.3.4 Major Flood Record

No.	Record of Cyclone					Maximum Rainfall for Various Duration (mm) [3]						Water Level of Laoag River at Gilbert Br. [4]	Observed Flood Mark at Dam Site [5] Water Depth (m)				
	Date		Name [1]		Inundation Depth (m) [2]	3 - hr	6 - hr	12 - hr	1-day	2 - day	3 - day		Labugaon	Solsona	Madongan	Papa	Nueva Era
1	1961	Jul 10 - 14	TD	-	-	195	310	341	495	671	785	-	-	-	-	-	-
2	1961	Aug 22 - 25	TY	Loma	-	117	166	221	288	513	572	7.78	-	-	-	-	-
3	1962	Jul 18 - 23	TY	Kate	-	93	106	170	255	491	672	-	-	-	-	-	-
4	1962	Aug 29 - 31	TY	Wanda	-	165	241	345	409	468	496	9.83	-	-	-	-	-
5	1963	Jun 04 - 09	TS	Bebeng	-	70	139	189	295	472	629	-	-	-	-	-	-
6	1967	Jun 27 - 29	TY	Gening	3.0	213	287	371	510	557	558	9.90	-	-	-	-	-
7	1973	Sep 01 - 03	TY	Huling	-	-	-	-	321	496	517	-	-	-	-	-	-
8	1977	Jul 23 - 25	TY	Goring	3.0	75	144	213	240	306	347	8.88	-	-	-	-	-
9	1984	Aug 27 - 30	TS	Maring	-	48	66	85	149	273	366	-	4.5	2.1	1.7	3.7	4.0
10	1985	Jun 21 - 25	TY	Kuring	1.6	-	-	-	222	337	440	-	6.0	3.2	1.7	0.5	1.9
11	1986	Jul 7 - 10	TY	Gading	-	-	-	-	94	179	231	8.30	1.8	1.8	1.7	1.7	1.9
12	1986	Aug30-Sep3	TY	Miding	2.0	70	84	167	214	350	476	9.42	2.0	2.5	1.9	2.5	5.7
13	1987	Oct 23 - 25	TY	Pepang	-	-	-	-	158	280	309	-	3.0	2.9	1.9	2.0	3.6
14	1989	Sep 08 - 11	TY	Openg	1.2	202	253	344	437	658	831	5.25	2.8	2.9	1.0	2.3	4.3
15	1992	Sep 19 - 22	TS	Maring	2.0	-	-	-	265	450	467	9.00	2.7	3.8	1.7	-	1.9
16	1994	Sep 09 - 11	TD	Weling	1.0	159	290	401	447	449	449	7.60	-	-	-	-	-

1): TD: Tropical Depression; TS: TropicalStorm TY: Typhoon

2): Interview survey results on the maximum inundation depth above main road surface.

3): Rainfall data at Laoag (PAGASA)

4): Elevation of water level converted to JICA datums

5): Water depth is estimated by : FEL - CEL ; FEL = flood elevation observed by INIP Irrigation Systems of NIA, CEL = crown elevation of dam

- : Not available

(shaded) : Biggest five (5) rainfall for various duraiton; highest five (5) water level at Gilbert Br. and Cauplasan Br. ; deepest five (5) inundation depth; and highest three (3) flood mark water level at Labugaon, Solsona, Madongan, Papa and Nueva Era dams

Table B.3.5 Water Level and Discharge Record

Year	Date	Water Level (m)			Discharge (m3/s)
		Gauge Record	Datums *		
			1984 Year	1996 Year	
1959	-	5.48	5.21	6.46	3,900
1960	-	5.52	5.25	6.50	4,000
1961	Aug. 25	6.80	6.53	7.78	6,200
1962	Aug. 30	8.85	8.58	9.83	10,800
1963	Sept. 5	6.87	6.60	7.85	6,300
1964	Sept. 9	7.00	6.73	7.98	6,600
1965	Sept. 3	5.63	5.36	6.61	4,100
1966	Nov. 2	3.00	2.73	3.98	1,100
1967	Jun 28	-	-	9.9 **	10,900
1968	Jul. 25	6.78	6.51	7.76	6,100
1969	Jul. 27	7.83	7.56	8.81	8,300
1970	Sept. 7	5.46	5.19	6.44	3,900
1971	Oct. 11	5.50	5.23	6.48	3,900
1972	Jul. 19	6.80	6.53	7.78	6,200
1973	Oct. 9	7.80	7.53	8.78	8,300
1974	Oct. 2	3.30	3.03	4.28	1,300
1975	Jun. 13	3.86	3.59	4.84	1,800
1976	Aug. 16	3.75	3.48	4.73	1,700
1977	Jul. 24	7.90	7.63	8.88	8,500
1978	-	-	-	-	-
1979	-	-	-	-	-
1980	-	-	-	-	-
1981	-	-	-	-	-
1982	-	-	-	-	-
1983	-	-	-	-	-
1984	Aug. 28	4.17	4.17	5.42	2,500
1985	Oct. 26	4.07	4.07	5.32	2,400
1986	Sept. 3	8.17	8.17	9.42	9,700
1987	Sept. 9	5.20	5.20	6.45	3,900
1988	Jul. 18	5.08	5.08	6.33	3,700
1989	Sept. 11	4.00	4.00	5.25	2,300
1990	Oct. 6	6.00	6.00	7.25	5,200
1991	Jun 22	5.20	5.20	6.45	3,900
1992	Sep 21	-	-	9.0 **	8,700
1993	Aug. 19	3.42	3.42	4.67	1,700
1994	Sept. 11	6.35	6.35	7.60	5,800
1995	Aug. 30	3.70	3.70	4.95	1,900

* : Datum line of water level gauge was ammended in 1984 by DPWH.
Datum line of water level gauge was converted by JICA Study in 1996.
**: Flood maximum water level was confirmed by interview survey and topographic survey.

Table B.3.6 Altitude Conversion Factor

Basin	Area (km2)	Average Elevation (m)	Altitude Conversion Factor	
			3-hr	24-hr
BO1	57.0	658	1.21	1.26
BO2	45.2	118	1.00	1.00
BO3	24.5	76	0.98	0.98
BO4	68.1	98	0.99	0.99
PA	51.4	682	1.22	1.27
BO5	22.9	93	0.99	0.99
BO6	85.6	70	0.98	0.98
MA1	105.8	812	1.18	1.22
MA2	42.3	726	1.15	1.19
MA3	5.7	274	0.98	0.98
SO2	10.7	487	1.05	1.06
SO1	79.0	742	1.15	1.18
SO4	14.9	77	0.91	0.89
SO3	57.2	72	0.91	0.89
CU1	69.5	643	1.11	1.13
LB	100.5	737	1.15	1.18
CU2	21.0	489	1.05	1.06
CU3	83.7	62	0.95	0.94
GU	178.3	162	1.03	1.04
LA1	50.0	63	1.01	1.01
LA2	38.1	38	1.00	1.01
LA3	43.0	27	1.00	1.00
LA4	15.1	4	1.00	1.00
LA5	62.6	37	1.01	1.01

Rainfall Station	Laoag	Piddig	Solsona	Nueva Era
Elevation (m)	5	25	350	125

Table B.3.7 Recorded Maximum Rainfall at Laoag Station
(1961-1995)

Year	Daily Rainfall (mm)	Date	2 Days Rainfall (mm)	Date	3 Days Rainfall (mm)	Date
1961	494.8	Jul 13	670.8	Jul 12-13	785.1	Jul 11-13
1962	409.2	Aug 30	491.3	Jul 19-20	672.1	Jul 19-21
1963	294.9	Jun 08	471.7	Jun 07-08	629.4	Jun 06-08
1964	162.9	Sep 03	221.3	Sep 09-10	268.6	Sep 08-10
1965	280.6	Sep 02	304.5	Sep 02-03	317.3	Sep 01-03
1966	136.2	Sep 06	229.2	Sep 05-06	261.2	Sep 04-06
1967	510.3	Jun 28	557.2	Jun 28-29	557.5	Jun 27-29
1968	248.5	Jul 24	308.2	Jul 23-24	337.1	Jul 23-25
1969	323.6	Sep 13	482.1	Sep 12-13	526.6	Sep 12-14
1970	93.5	Jun 13	165.6	Jun 12-13	226.8	Jun 12-14
1971	225.2	Oct 09	393.3	Oct 09-10	472.1	Oct 09-11
1972	249.7	Jul 18	358.7	Jul 17-18	438.7	Jul 16-18
1973	320.6	Sep 03	496.4	Sep 02-03	516.8	Sep 01-03
1974	162.9	Jun 04	274.7	Jun 03-04	359.3	Jun 02-04
1975	125.7	Aug 14	221.0	Aug 14-15	261.9	Aug 14-16
1976	128.4	May 26	219.1	May 25-26	228.2	May 25-27
1977	243.0	Aug 20	396.2	Aug 19-20	428.5	Aug 19-21
1978	157.0	Jun 23	195.2	Jun 23-24	240.4	Jun 22-23
1979	183.4	Jul 27	226.3	Jul 27-28	258.7	Jul 27-29
1980	215.2	Jul 09	280.9	Jul 09-10	300.5	Jul 08-10
1981	133.6	Jun 12	143.5	Jun 11-12	203.0	Jun 12-14
1982	189.0	Jul 02	356.0	Jul 02-03	388.7	Jul 02-04
1983	180.9	Sep 06	223.7	Sep 06-07	295.3	Aug 12-14
1984	187.2	Apr 30	284.2	Apr 29-30	365.7	Aug 27-29
1985	221.8	Jun 22	337.2	Jun 22-23	439.6	Jun 21-23
1986	228.2	Aug 22	350.3	Sep 01-02	475.5	Aug 31-Sep 02
1987	157.6	Oct 24	279.7	Oct 23-24	309.3	Oct 23-25
1988	139.7	Jun 01	169.9	Jun 01-02	187.1	May 31-Jun 02
1989	437.2	Sep 09	658.1	Sep 09-10	830.6	Sep 09-11
1990	235.7	Aug 18	372.6	Aug 29-30	467.0	Aug 29-31
1991	240.0	Aug 12	380.4	Aug 12-13	381.7	Aug 12-14
1992	265.0	Sep 21	450.4	Sep 20-21	467.2	Sep 19-21
1993	361.8	Sep 15	378.6	Sep 15-16	378.6	Sep 15-17
1994	446.8	Sep 10	448.6	Sep 9-10	448.6	Sep 9-11
1995	224.2	Aug 30	402.2	Aug 29-30	409.8	Aug 28-30
Average	246.1		348.5		403.8	

Table B.3.8 Probable Maximum Rainfall

(Unit: mm)

Return Period (Year)	Hazen Method			Gumbel Method			Log-normal Method			Iwai Method			Isihara-Takase Method		
	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day
2	226	325	377	228	327	378	226	325	377	218	325	373	227	333	376
5	320	449	515	324	444	516	321	450	516	321	446	515	323	451	515
10	385	531	606	388	521	608	387	534	608	401	520	613	387	523	607
20	448	611	693	448	596	695	451	615	697	484	587	710	449	589	697
25	468	636	721	468	619	723	471	641	725	512	607	741	469	610	725
30	484	657	744	483	638	746	488	662	748	535	623	766	485	626	748
50	531	715	807	527	692	809	535	721	811	602	666	838	531	671	813
100	594	794	892	586	764	894	600	801	898	699	721	937	593	730	902
150	632	841	942	620	806	943	639	849	949	759	751	996	629	764	955
200	660	874	978	645	836	978	667	883	986	803	772	1,039	655	788	992
500	748	982	1,094	722	931	1,090	757	992	1,103	951	835	1,177	740	863	1,113

Table B.4.1 Constants for Storage Function Model

Constants for Sub-basin

Sub-Basin	Catchment Area (km^2)	River Length (km)	Equivalent Roughness (N)	Slope I	Constants K	T (hr.)
BO1	57.0	10.4	0.7	0.09529	10.8	0.22
BO2	45.2	11.5	1.0	0.03826	16.7	0.27
BO3	24.5	9.6	1.5	0.00604	31.9	0.18
BO4	68.1	16.5	0.5	0.02521	14.2	0.52
PA	51.4	10.5	0.7	0.09219	10.6	0.22
BO5	22.9	8.8	0.7	0.02977	12.4	0.14
BO6	85.6	11.0	2.0	0.00545	52.6	0.25
MA1	105.8	26.5	0.7	0.05736	14.6	1.03
MA2	42.3	13.5	0.7	0.09778	10.0	0.37
MA3	5.7	1.6	0.7	0.03750	8.2	0.00
SO2	10.7	5.4	0.7	0.14630	6.3	0.00
SO1	79.0	18.0	0.7	0.08083	12.3	0.60
SO4	14.9	6.6	2.0	0.00803	30.8	0.02
SO3	57.2	9.5	2.0	0.00832	42.1	0.17
CU1	69.5	16.3	0.7	0.07147	12.3	0.51
LB	100.5	19.8	0.7	0.07222	13.4	0.69
CU2	21.0	11.0	0.7	0.06500	9.5	0.25
CU3	83.7	15.2	1.8	0.00559	49.0	0.46
GU	178.3	27.4	1.3	0.01679	34.4	1.08
LA1	50.0	17.0	1.7	0.00588	41.4	0.55
LA2	38.1	9.0	1.8	0.00389	45.7	0.15
LA3	43.0	6.0	1.9	0.00417	46.6	0.00
LA4	15.1	2.0	2.0	0.00050	71.1	0.00
LA5	62.6	18.5	1.3	0.00297	45.0	0.63

Constants for River Channel

River Channel	River Length (km)	River Width (m)	Manning's Roughness (n)	Slope I	Constants K	T (hr.)
R1	6.8	350	0.04	0.00667	12.8	0.14
R2	2.5	300	0.04	0.00400	5.1	0.06
R3	2.5	330	0.04	0.00250	6.1	0.08
R4	7.4	220	0.04	0.01250	9.6	0.11
R5	3.9	400	0.035	0.00143	11.5	0.17
R6	5.9	560	0.035	0.00143	19.6	0.26
R7	1.6	350	0.04	0.01429	2.4	0.02
R8	8.9	300	0.04	0.01000	14.0	0.15
R9	9.5	200	0.04	0.00832	13.4	0.17
R10	6.5	230	0.04	0.01250	8.6	0.10
R11	2.6	260	0.04	0.00286	5.6	0.08
R12	2.1	370	0.04	0.00167	6.1	0.08
R13	1.1	750	0.04	0.00100	5.1	0.06
R14	15.2	410	0.04	0.00593	31.5	0.32
R15	5.3	600	0.035	0.00083	21.3	0.30
R16	7.3	750	0.035	0.00083	32.2	0.42
R17	5.2	1200	0.035	0.00067	29.5	0.33
R18	5.3	800	0.035	0.00067	25.6	0.34
R19	8.3	1200	0.035	0.00053	50.7	0.60

Table B.4.2 Basin Mean Rainfall by Model Hyetograph

(Unit: mm)

	Period	BO1	BO2	BO3	BO4	PA	BO5	BO6	MA1	MA2	MA3	SO2	SO1	SO4	SO3	CU1	LB	CU2	CU3	GU	LA1	LA2	LA3	LA4	LA5
Jul 24	0:00 - 1:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.56	0.48	0.43	0.53	0.55	0.43	0.41	0.53	0.54	0.52	0.22	0.06	0.00	0.00	0.00	0.00	0.00
	1:00 - 2:00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	2.52	2.17	1.94	2.37	2.49	1.95	1.82	2.37	2.42	2.35	1.00	0.26	0.00	0.00	0.00	0.00	0.00
	2:00 - 3:00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.84	0.72	0.65	0.79	0.83	0.65	0.63	0.79	0.81	0.78	0.75	0.87	0.89	0.97	0.81	0.00	0.05
	3:00 - 4:00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	2.24	1.93	1.73	2.10	2.21	1.73	1.73	2.11	2.15	2.08	2.74	3.76	4.02	4.38	3.63	0.00	0.21
	4:00 - 5:00	5.34	4.28	4.28	4.14	5.49	4.37	3.51	8.39	8.06	6.95	7.89	8.30	6.49	6.12	7.91	8.06	7.82	3.96	2.05	1.64	1.46	1.44	1.47	1.43
	5:00 - 6:00	4.16	3.33	3.33	3.22	4.27	3.40	3.24	3.36	3.54	2.96	3.16	3.32	2.60	2.53	3.16	3.22	3.13	2.98	3.48	3.81	3.89	3.99	4.90	4.70
	6:00 - 7:00	7.13	5.70	5.70	5.52	7.32	5.82	7.83	5.04	5.44	4.53	4.74	4.98	3.89	4.02	4.75	4.84	4.69	8.18	12.27	13.80	14.59	12.94	5.39	5.68
	7:00 - 8:00	15.44	12.35	12.35	11.96	15.85	12.61	8.66	3.92	5.76	4.41	3.68	3.87	3.03	2.99	3.69	3.76	3.65	4.03	5.11	6.23	5.84	5.45	3.92	3.90
	8:00 - 9:00	19.00	15.20	15.20	14.72	19.51	15.52	10.09	7.55	9.45	7.53	7.10	7.47	5.84	5.58	7.12	7.25	7.04	4.86	4.31	5.09	4.38	5.78	13.72	12.85
	9:00 - 10:00	0.59	0.48	0.48	0.46	0.61	0.49	2.75	15.39	13.36	11.92	14.47	15.22	11.90	11.23	14.50	14.77	14.33	7.57	4.35	3.16	3.40	3.36	3.43	3.33
	10:00 - 11:00	16.63	13.30	13.30	12.88	17.07	13.58	10.11	9.23	10.53	8.62	8.68	9.13	7.14	6.87	8.70	8.86	8.60	6.77	6.84	7.64	7.29	8.04	12.74	12.09
	11:00 - 12:00	14.85	11.88	11.88	11.50	15.25	12.13	10.80	3.36	5.19	3.92	3.16	3.32	2.60	2.79	3.16	3.22	3.13	7.31	11.70	13.79	14.10	13.15	9.31	9.26
	12:00 - 13:00	14.85	11.88	11.88	11.50	15.25	12.13	7.55	11.47	12.18	10.18	10.79	11.34	8.87	8.32	10.81	11.01	10.68	4.78	1.59	1.29	0.49	0.56	0.98	0.93
	13:00 - 14:00	5.94	4.75	4.75	4.60	6.10	4.85	4.83	7.55	7.43	6.36	7.10	7.47	5.84	5.61	7.12	7.25	7.04	5.27	5.10	5.25	5.35	5.43	6.37	6.13
	14:00 - 15:00	8.91	7.13	7.13	6.90	9.15	7.28	6.38	7.55	7.89	6.63	7.10	7.47	5.84	5.63	7.12	7.25	7.04	5.69	5.88	6.31	6.32	6.62	8.82	8.43
	15:00 - 16:00	3.56	2.85	2.85	2.76	3.66	2.91	2.07	2.80	2.96	2.48	2.63	2.77	2.16	2.05	2.64	2.69	2.61	1.53	1.08	1.09	0.97	1.04	1.47	1.40
	16:00 - 17:00	0.59	0.48	0.48	0.46	0.61	0.49	0.95	4.20	3.71	3.29	3.95	4.15	3.25	3.06	3.95	4.03	3.91	2.08	1.22	0.93	0.97	0.96	0.98	0.95
	17:00 - 18:00	0.59	0.48	0.48	0.45	0.61	0.49	0.41	1.68	1.54	1.35	1.58	1.66	1.30	1.22	1.58	1.61	1.56	0.67	0.18	0.03	0.00	0.00	0.00	0.00
	18:00 - 19:00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	1.96	1.69	1.51	1.84	1.94	1.51	1.42	1.85	1.88	1.82	0.78	0.20	0.00	0.00	0.00	0.00	0.00
	19:00 - 20:00	0.59	0.48	0.48	0.45	0.61	0.49	0.74	5.04	4.43	3.94	4.74	4.98	3.89	3.65	4.75	4.84	4.69	2.01	0.53	0.03	0.00	0.00	0.00	0.00
	20:00 - 21:00	0.00	0.00	0.00	0.00	0.00	0.00	1.24	3.92	3.38	3.02	3.68	3.87	3.03	2.91	3.69	3.76	3.65	2.80	2.76	2.68	2.92	2.88	2.94	2.85
	21:00 - 22:00	0.59	0.48	0.48	0.46	0.61	0.49	2.81	1.12	1.06	0.92	1.05	1.11	0.87	1.02	1.05	1.07	1.04	3.95	6.77	7.62	8.27	8.24	8.82	8.53
	22:00 - 23:00	8.31	6.65	6.65	6.44	8.54	6.79	5.81	2.80	3.70	2.91	2.63	2.77	2.16	2.20	2.64	2.69	2.61	4.00	5.77	6.72	6.81	7.26	10.29	9.81
	23:00 - 0:00	4.16	3.33	3.33	3.22	4.27	3.40	2.39	1.96	2.33	1.88	1.84	1.94	1.51	1.46	1.85	1.88	1.82	1.40	1.38	1.57	1.46	2.44	7.84	7.29
Jul. 25	0:00 - 1:00	3.56	2.85	2.85	2.76	3.66	2.91	3.71	7.83	7.30	6.36	7.37	7.75	6.06	5.80	7.38	7.52	7.30	5.18	4.73	4.67	4.86	4.80	4.90	4.75
	1:00 - 2:00	0.00	0.00	0.00	0.00	0.00	0.00	2.11	12.87	11.09	9.93	12.10	12.73	9.95	9.40	12.13	12.36	11.99	6.36	3.69	2.68	2.92	3.34	5.88	5.56
	2:00 - 3:00	1.78	1.43	1.43	1.38	1.83	1.46	3.58	8.39	7.51	6.63	7.89	8.30	6.49	6.25	7.91	8.06	7.82	6.23	6.36	6.35	6.81	5.64	0.00	0.33
	3:00 - 4:00	4.75	3.80	3.80	3.68	4.88	3.88	7.82	1.96	2.42	1.94	1.84	1.94	1.51	1.91	1.85	1.88	1.82	8.81	15.47	17.68	18.97	17.80	13.23	13.11
	4:00 - 5:00	23.16	18.53	18.53	17.94	23.78	18.92	13.85	5.87	8.65	6.61	5.52	5.81	4.54	4.56	5.54	5.64	5.47	7.28	10.01	12.02	11.67	10.91	7.84	7.79
	5:00 - 6:00	19.00	15.20	15.20	14.72	19.51	15.52	9.42	3.64	6.07	4.51	3.42	3.60	2.81	2.72	3.43	3.49	3.39	2.89	3.12	4.20	3.40	3.82	6.37	6.03
	6:00 - 7:00	46.91	37.53	37.53	36.34	48.17	38.32	25.01	26.01	29.68	24.29	24.46	25.73	20.12	19.07	24.52	24.98	24.23	14.07	9.77	10.69	8.75	8.49	7.84	7.65
	7:00 - 8:00	48.69	38.95	38.95	37.72	50.00	39.77	23.25	19.30	24.17	19.27	18.15	19.09	14.93	14.04	18.19	18.53	17.98	8.72	3.98	4.99	2.43	2.02	0.00	0.12
	8:00 - 9:00	11.83	9.50	9.50	9.20	12.20	9.70	15.30	25.73	24.02	20.92	24.20	25.45	19.91	19.32	24.25	24.71	23.97	21.37	23.83	24.78	26.26	24.61	18.13	17.98
	9:00 - 10:00	33.85	27.08	27.08	26.22	34.76	27.65	23.42	38.60	38.51	32.82	36.30	38.18	29.86	28.42	36.38	37.07	35.96	23.00	18.52	18.43	17.99	16.53	10.29	10.36
	10:00 - 11:00	21.97	17.58	17.58	17.02	22.56	17.95	12.76	16.22	17.39	14.49	15.26	16.05	12.55	11.91	15.29	15.58	15.11	9.14	6.79	7.05	6.32	6.01	4.90	4.82
	11:00 - 12:00	33.85	27.08	27.08	26.22	34.76	27.65	24.97	26.29	27.90	23.33	24.73	26.01	20.34	19.75	24.78	25.25	24.49	22.01	24.67	26.91	27.23	23.04	2.94	4.04
	12:00 - 13:00	59.28	49.40	49.40	47.84	60.32	50.44	34.22	26.29	32.22	25.84	24.73	26.01	20.34	19.52	24.78	25.25	24.49	18.30	17.63	20.46	18.48	20.47	32.83	31.14
	13:00 - 14:00	46.17	38.48	38.48	37.26	46.98	39.29	30.09	45.04	46.27	39.07	42.35	44.54	34.84	33.08	42.44	43.25	41.95	25.57	19.19	19.24	17.99	15.99	6.86	7.20
	14:00 - 15:00	40.47	33.73	33.73	32.66	41.18	34.44	32.63	64.74	62.15	56.02	62.92	64.74	53.85	51.20	62.32	63.53	62.32	39.27	29.39	27.83	27.72	27.21	26.95	26.17
	15:00 - 16:00	42.16	33.73	33.73	32.66	43.30	34.44	36.30	33.97	35.59	31.20	33.02	33.97	28.26	27.83	32.70	33.34	32.70	36.08	44.43	48.81	50.57	49.77	49.98	48.50
	16:00 - 17:00	30.88	24.70	24.70	23.92	31.71	25.22	38.13	51.09	48.70	44.00	49.66	51.09	42.50	41.61	49.18	50.14	49.18	50.42	59.61	63.35	66.24	62.86	46.06	45.70
	17:00 - 18:00	27.91	22.33	22.33	21.62	28.66	22.80	21.55	31.89	31.81	27.11	29.99	31.54	24.67	23.67	30.05	30.62	29.70	22.18	21.34	22.11	22.08	23.16	29.40	28.17
	18:00 - 19:00	30.88	24.70	24.70	23.92	31.71	25.22	32.57	22.66	24.31	20.26	21.31	22.41	17.53	17.92	21.35	21.76	21.11	33.73	49.35	55.32	57.60	55.45	45.08	44.37
	19:00 - 20:00	30.29	24.23	24.23	23.46	31.10	24.74	20.83	18.46	20.60	16.97	17.36	18.26	14.28	13.91	17.40	17.73	17.20	16.21	18.77	20.91	20.91	20.10	17.64	17.27
	20:00 - 21:00	13.06	10.45	10.45	10.12	13.42	10.67	12.20	25.73	24.21	21.03	24.20	25.45	19.91	19.00	24.25	24.71	23.97	16.23	14.04	13.68	14.10	12.69	6.37	6.56
	21:00 - 22:00	14.25	11.40	11.40	11.04	14.64	11.64	10.78	20.70	20.05	17.25	19.47	20.47	16.01	15.23	19.51	19.88	19.28	12.16	9.60	9.29	9.24	8.43	4.90	4.96
	22:00 - 23:00	28.50	22.80	22.80	22.08	29.27	23.28	18.96	11.47	14.30	11.41	10.79	11.34	8.87	8.81	10.81	11.01	10.68	12.80	16.86	19.47	19.45	17.97	11.76	11.78
	23:00 - 0:00	21.97	17.58	17.58	17.02	22.56	17.95	13.91	13.15	14.73	12.12	12.36	13.00	10.17	9.81	12.39	12.62	12.25	9.97	10.38	11.51	11.18	10.20	5.88	5.96
Jul. 26	0:00 - 1:00	11.28	9.03	9.03	8.74	11.59	9.22	9.41	19.58	18.63	16.12	18.41	19.37	15.15	14.42	18.45	18.80	18.24	11.72	9.49	9.12	9.24	8.74	6.86	6.77
	1:00 - 2:00	20.78	16.63	16.63	16.10	21.34	16.98	13.46	13.71	15.03	12.44	12.89	13.56	10.60	10.22	12.92	13.16	12.77	10.20	10.44	11.44	11.18	10.04	4.90	5.06
	2:00 - 3:00	30.88	24.70	24.70	23.92	31.71	25.22	17.14	8.95	12.49	9.68	8.42	8.85	6.92	6.76	8.41	8.60	8.34	8.10	9.55	11.57	10.70	9.95	6.86	6.84
	3:00 - 4:00	8.91	7.13	7.13	6.90	9.15	7.28	7.32	18.74	17.53	15.26	17.62	18.54	14.50	13.73	17.66	18.00	17.46	9.94	6.66	5.86	5.84	5.84	6.37	6.15
	4:00 - 5:00	14.85	11.88	11.88	11.50	15.25	12.13	10.36	22.66	21.83	18.82	21.31	22.41	17.53	16.57	21.35	21.76	21.11	11.71	7.46	6.64	6.32	7.01	11.27	10.69
	5:00 - 6:00	11.88	9.50	9.50	9.20	12.20	9.70	10.51	8.95	9.55	7.97	8.42	8.85	6.92	6.88	8.44	8.60	8.34	10.15	13.46	14.96	15.56	14.05	7.35	7.53
	6:00 - 7:00	17.82	14.25	14.25	13.80	18.29	14.55	12.90	12.03	13.13	10.88	11.31	11.90	9.30	9.08	11.34	11.55	11.20	10.76	12.61	13.95	14.10	12.84	7.35	7.46
	7:00 - 8:00	8.31	6.65	6.65	6.44	8.54	6.79	6.73	7.83	8.04	6.79	7.37	7.75	6.06	5.89	7.38	7.52	7.30	6.62	7.47	8.06	8.27	7.39	3.43	3.56
	8:00 - 9:00	5.34	4.28	4.28	4.14	5.49	4.37	5.72	8.95	8.54	7.39	8.42	8.85	6.92	6.71	8.44	8.60	8.34	7.27	7.98	8.34	8.75	8.64	8.82	8.55
	9:00 - 10:00	1.78	1.43	1.43	1.38	1.83	1.46	2.29	3.92	3.65	3.18	3.68	3.87	3.03	2.94	3.69	3.76	3.65	3.21	3.54	3.67	3.89	4.76	9.80	9.22
	10:00 - 11:00	0.59	0.48	0.48	0.46	0.61	0.49	1.19	6.71	5.88	5.23	6.31	6.64	5.19	4.89	6.33	6.45	6.25	3.09	1.49	0.93	0.97	1.19	2.45	2.30
	11:00 - 12:00	0.59	0.48	0.48	0.45	0.61	0.49	0.33	0.84	0.82	0.70	0.79	0.83	0.65	0.61	0.79	0.81	0.78	0.33	0.09	0.03	0.00	0.08	0.49	0.45
	12:00 - 13:00	0.00	0.00	0.00	0.00	0.00	0.00	2.19	0.28	0.24	0.22	0.26	0.28	0.22	0.39	0.26	0.27	0.26	3.20	5.90	6.70	7.29	6.51	2.94	3.06
	13:00 - 14:00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	7.27	6.27	5.61	6.84	7.19	5.63	5.27	6.85	6.98	6.77	2.90	0.76	0.00	0.00	1.08	6.86	6.32
	14:00 - 15:00	2.38	1.90	1.90	1.84	2.44	1.94	1.28	2.80	2.78	2.37	2.63	2.77	2.16	2.03	2.64	2.69	2.61	1.11	0.29	0.13	0.00	0.38	2.45	2.26
	15:00 - 16:00	7.13	5.70	5.70	5.52	7.32	5.82	7.27	6.71	6.89	5.82	6.31	6.64	5.19	5.18	6.33	6.45	6.25	7.82	10.49	11.56	12.16	10.08	0.00	0.59
	16:00 - 17:00	17.22	13.78	13.78	13.34	17.68	14.07	9.05	3.08	5.32	3.92	2.89	3.04	2.38	2.35	2.90	2.95	2.87	3.28	4.24	5.44	4.85	4.72	4.41	4.30
	17:00 - 18:00	5.94	4.75	4.75	4.60	6.10	4.85	6.57	6.15	6.22	5.28	5.79	6.09	4.76	4.76	5.80	5.91	5.73	7.39	10.04	11.05	11.67	10.29	3.92	4.18
	18:00 - 19:00	1.19	0.95	0.95	0.92	1.22	0.97	2.32	8.39	7.42	6.58	7.89	8.30	6.49	6.17	7.91	8.06	7.82	4.79	3.62	3.19	3.40	3.97	7.35	6.94
	19:00 - 20:00	0.59	0.48	0.48	0.46	0.61	0.49	2.39	7.27	6.36	5.66	6.84	7.19	5.63	5.39	6.85	6.98	6.77	4.96	4.68	4.50	4.86	9.25	33.32	30.92
	20:00 - 21:00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	2.52	2.17	1.94	2.37	2.49	1.95	1.84	2.37	2.42	2.35	1.21	0.65	0.45	0.49	0.86	2.94	2.73
	21:00 - 22:00	0.00	0.00	0.00	0.00	0.00	0.00	2.39	0.84	0.72	0.65	0.79	0.83	0.65	0.81	0.79	0.81	0.78	3.63	6.35	7.14	7.78	8.52	13.23	12.56
	22:00 - 23:00	2.38	1.90	1.90	1.84	2.44	1.94	2.18	1.68	1.81	1.51	1.58	1.66	1.30	1.30	1.58	1.61	1.56	2.11	2.92	3.26	3.40	3.82	6.37	6.03
	23:00 - 0:00	1.19	0.95	0.95	0.92	1.22	0.97	0.87	0.84	0.91	0.75	0.79	0.83	0.65	0.63	0.79	0.81	0.78	0.75	0.87	0.96	0.97	0.88	0.49	0.50
Total		937.5	754.8	754.8	730.9	961.3	770.7	696.8	853.0	880.8	748.2	806.9	845.4	668.6	644.8	806.9	822.3	799.2	649.6	670.1	715.0	718.8	695.2	629.7	615.1

Table B.4.3 Comparison of Probable Discharges with Other Studies

1. This Study (The Study on Sabo and Flood Control in The Laoag River Basin, JICA)

River	Control Point	Catchment Area(km2)	Discharge (m3/s) / Specific Runoff (m3/s/km2)			
			10-yr	25-yr	50-yr	100-yr
Bongo	Nueva Era Dam	57.0	620 (10.9)	750 (13.2)	830 (14.6)	920 (16.1)
Papa	Papa Dam	51.4	570 (11.1)	690 (13.4)	770 (15.0)	850 (16.5)
Madongan	Madongan Dam	153.8	1610 (10.5)	1970 (12.8)	2220 (14.4)	2470 (16.1)
Solsona	Solsona Dam	79.0	840 (10.6)	1030 (13.0)	1150 (14.6)	1280 (16.2)
Labgaon	Labgaon Dam	100.5	1020 (10.1)	1260 (12.5)	1410 (14.0)	1570 (15.6)
Laoag	Gilbert Br.	1254.4	8900 (7.1)	10900 (8.7)	12300 (9.8)	13700 (10.9)

2. Detailed Design Report on Ilocos Norte Irrigation Project, NIA, 1981

River	Control Point	Catchment Area(km2)	Peak Discharge (m3/s) / Specific Runoff (m3/s/km2)			
			10-yr	20-yr	50-yr	100-yr
Gasgas (Solsona)	Manalpac	73.0	603 (8.3)	760 (10.4)	964 (13.2)	1116 (15.3)

River	Control Point	Catchment Area(km2)	Design Discharge (m3/s) 100-yr / Specific Runoff (m3/s/km2)
Bongo	Nueva Era Dam	57.0	870 (15.3)
Papa	Papa Dam	51.4	790 (15.4)
Madongan	Madongan Dam	153.8	2350 (15.3)
Solsona	Solsona Dam	79.0	1210 (15.3)
Labugaon	Labugaon Dam	100.5	1540 (15.3)

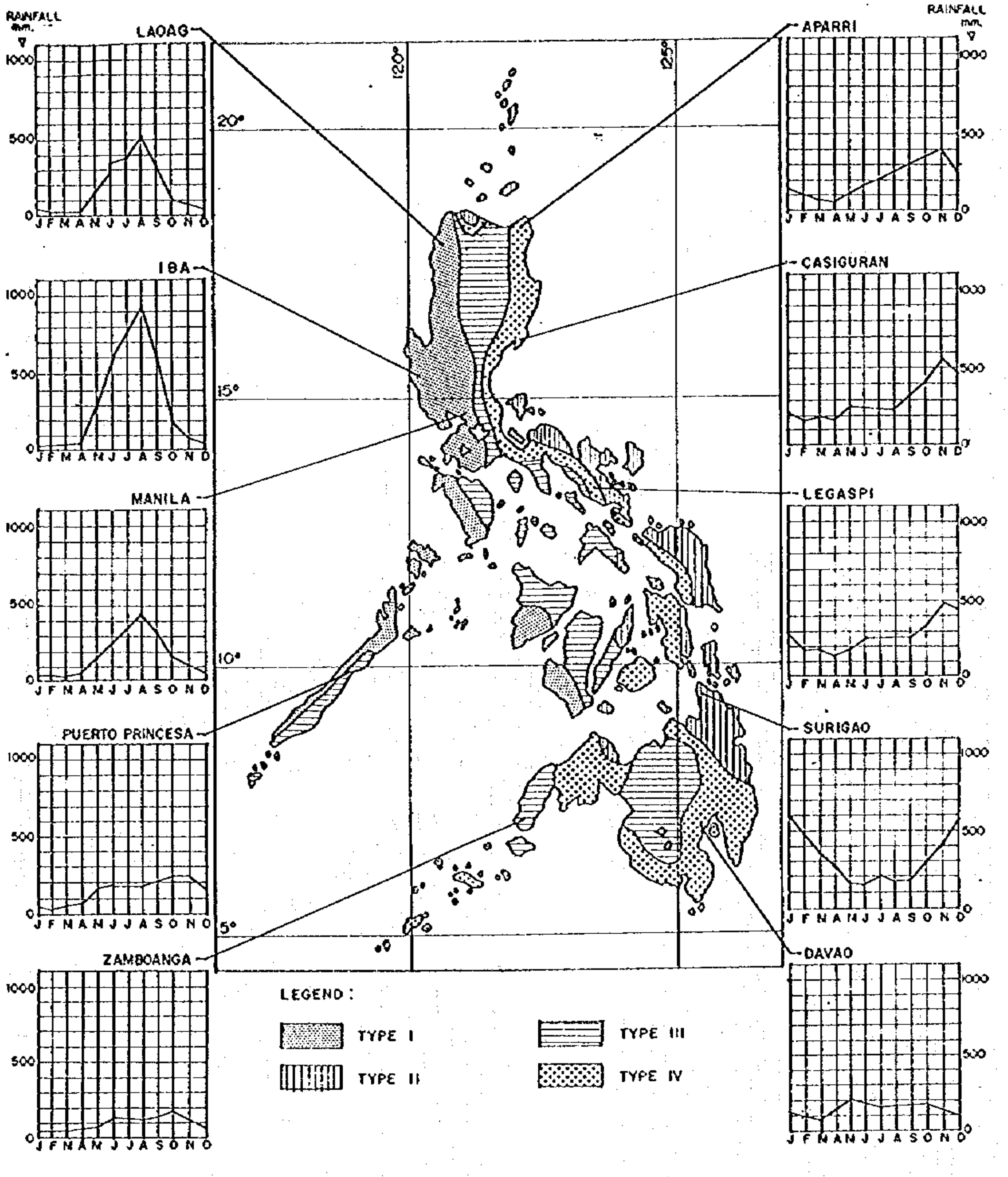
3. Nationwide Flood Control Plan and River Dredging Program, DPWH, 1982

River	Control Point	Catchment Area(km2)	Discharge (m3/s) / Specific Runoff (m3/s/km2)		
			10-yr	25-yr	50-yr
Papa	Banna (Espiritu)	103	880 (8.5)	1240 (12.0)	1420 (13.8)
Bongo	Banna (Espiritu)	108	1030 (9.5)	1280 (11.8)	1460 (13.5)
Madongan	Dingras	193	2070 (10.7)	2550 (13.2)	2930 (15.2)
Solsona	Manalpac	73			1460 (20.0)
Solsona	Dingras	163	1570 (9.6)	1940 (11.9)	2220 (13.6)
Cura	Dingras	289	2470 (8.5)	3060 (10.6)	3500 (12.1)
Guisit	Piddig	162	1360 (8.4)	1680 (10.4)	1920 (11.9)
Laoag	Laoag	1353	7360 (5.4)	9090 (6.7)	10500 (7.8)

4. Feasibility Study of the Tina-Gasgas-Cura Impounding Reservoir Project at Solsona, NIA, 1983

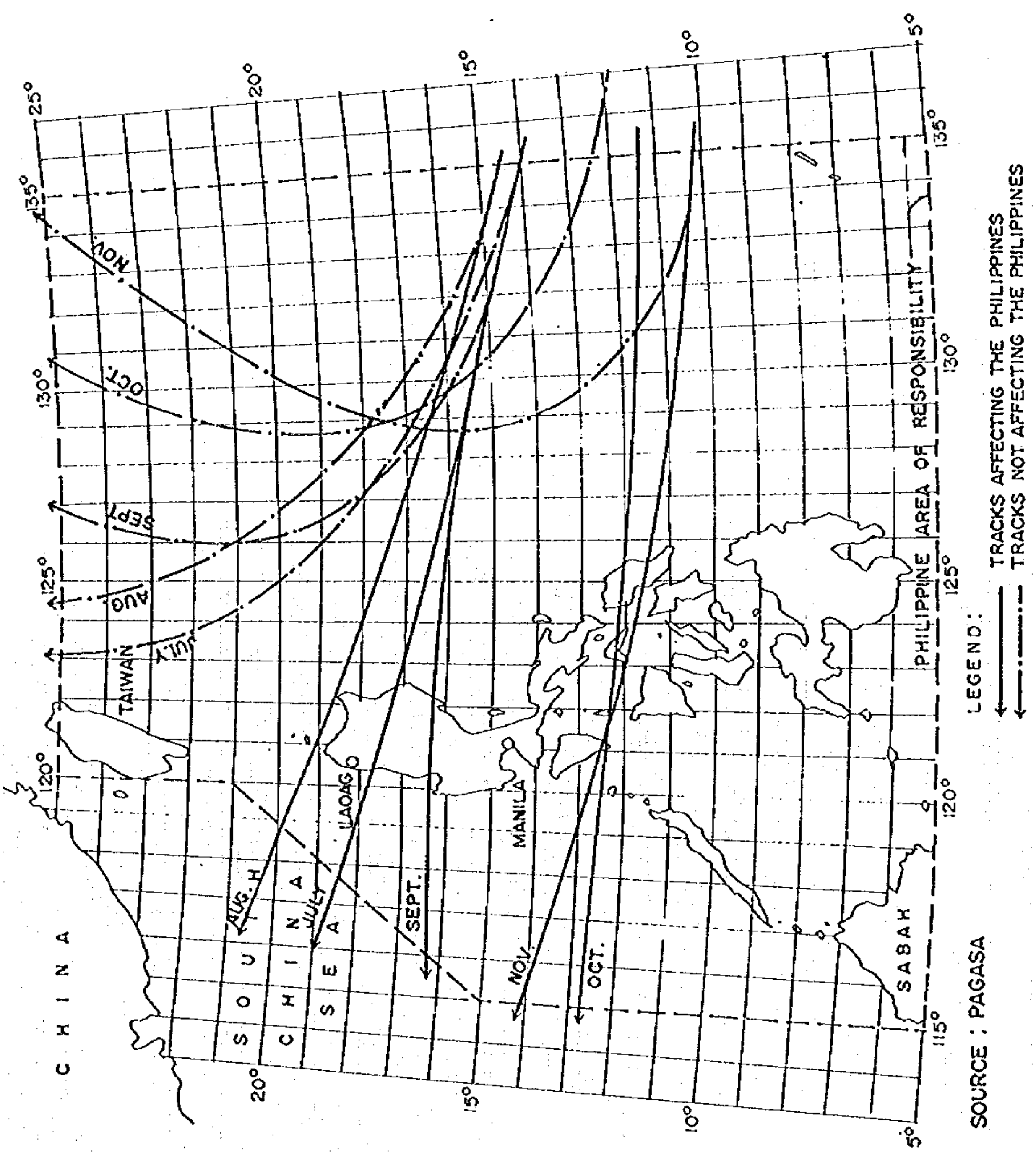
River	Control Point	Catchment Area(km2)	Discharge (m3/s) / Specific Runoff (m3/s/km2)		
			10-yr	25-yr	50-yr
Gasgas (Solsona)	Manalpac	73	478 (6.5)	743 (10.2)	979 (13.4)
Tina (Labugaon)	Maananteng	98	658 (6.7)	1024 (10.4)	1350 (13.7)
Cura	Carasi	63	422 (6.7)	656 (10.4)	865 (13.7)

FIGURES

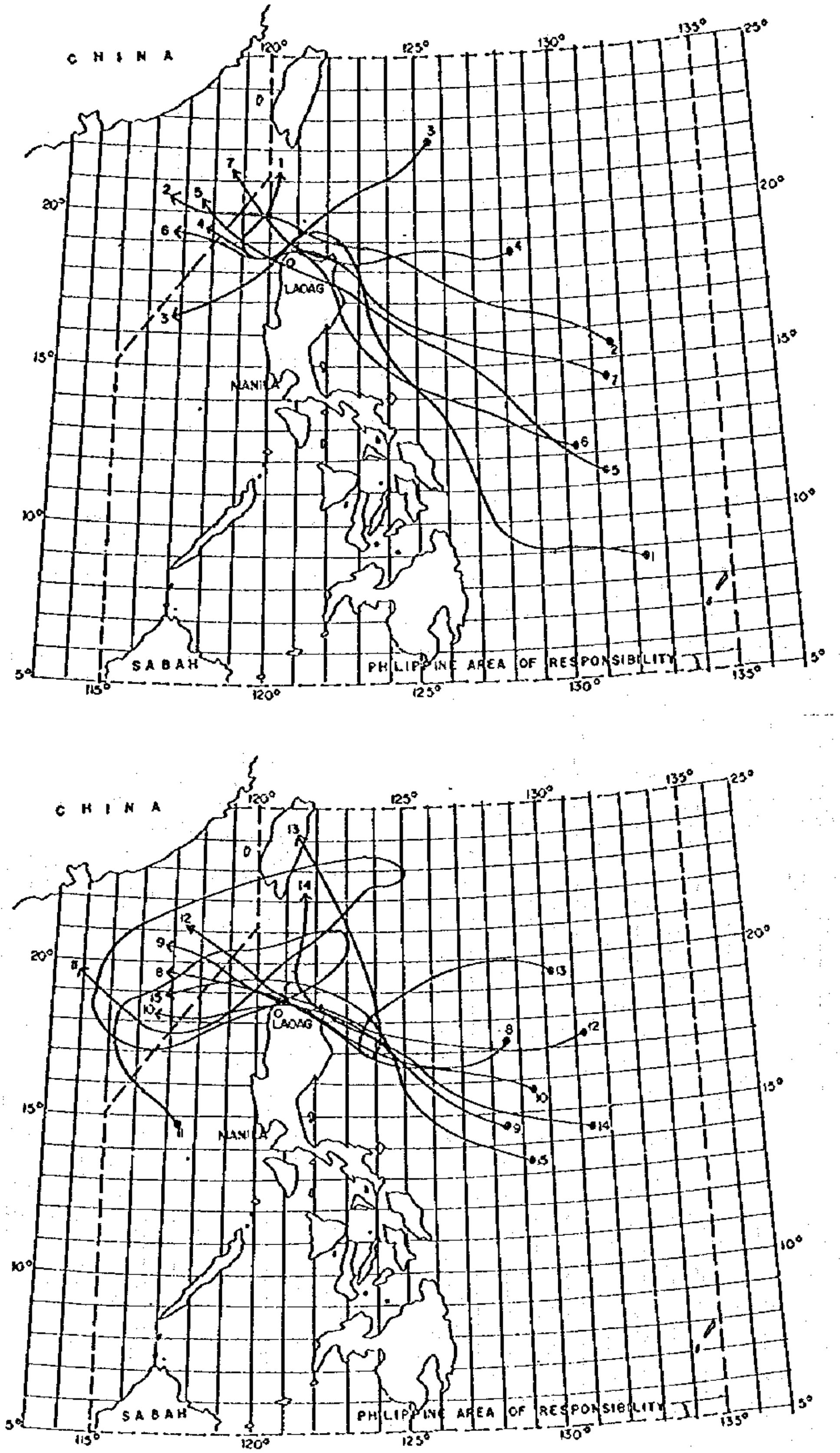


SOURCE : PAGASA

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. B.2.1 Climatic Classification in the Philippines
JAPAN INTERNATIONAL COOPERATION AGENCY	



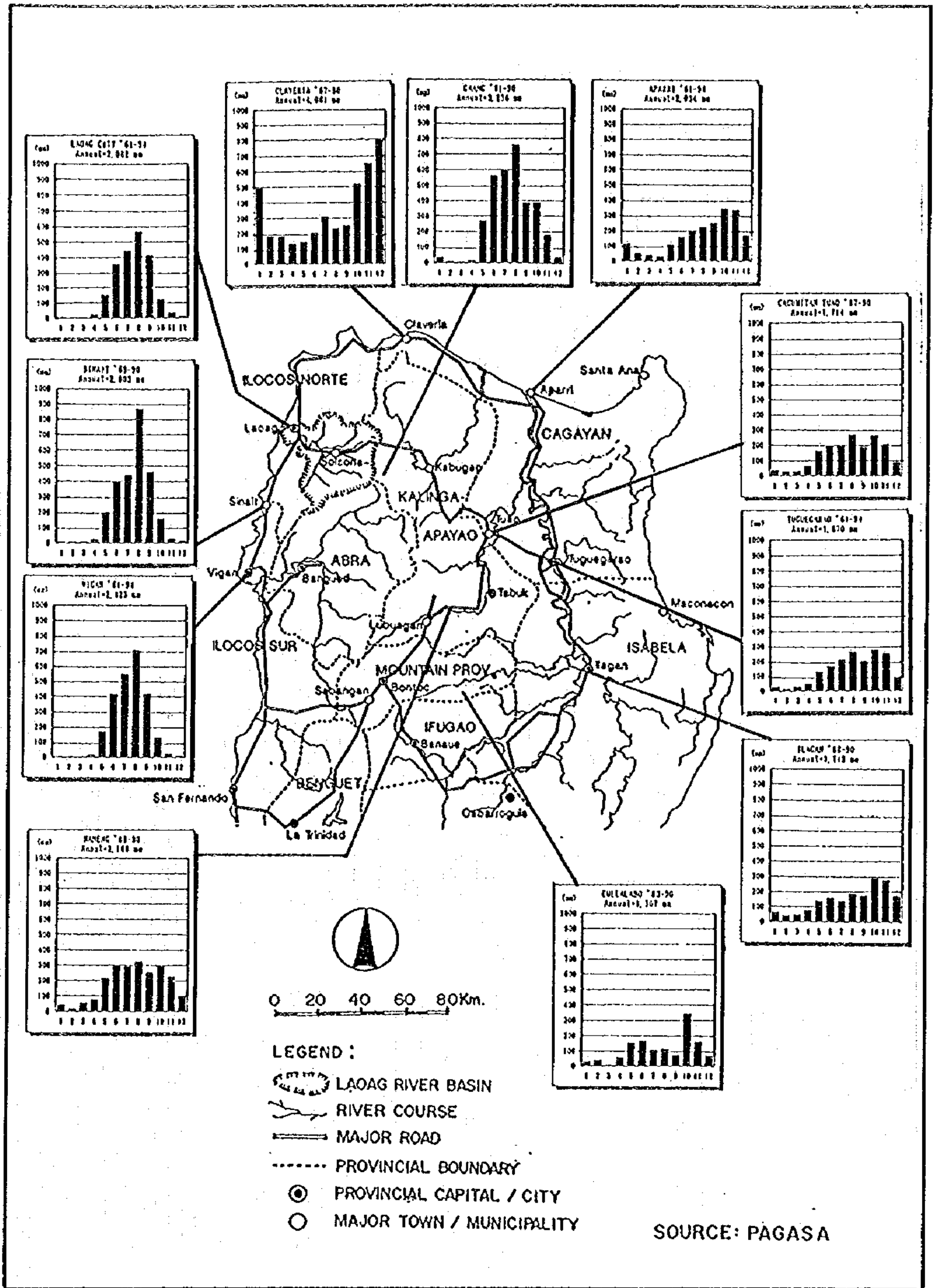
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.2.2 General Tracks of Tropical Cyclones Affecting the North Luzon



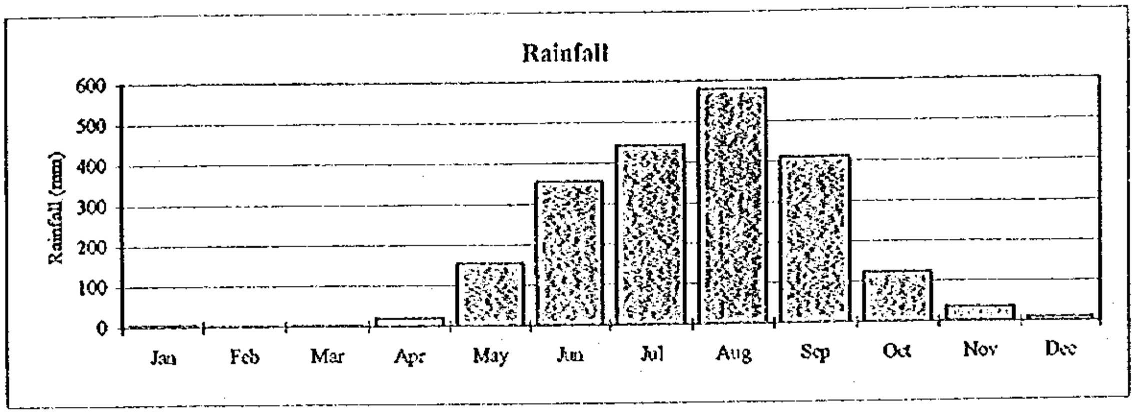
1. TY Kate
   Jul. 18-23 '62
2. TY Wanda
   Aug. 29-3 '62
3. TS Bebeng
   Jun. 04-09 '63
4. TY Yoning
   Sep. 02-04 '64
5. TY Gening
   Jun. 27-29 '67
6. TS Huling
   Sep. 01-03 '73
7. TY Goring
   Jun. 23-25 '77
8. TS Maring
   Aug. 27-30 '84
9. TY Kuring
   Jun. 21-25 '85
10. TY Gading
    Jul. 07-10 '86
11. TY Miding
    Aug.30-Sep. 03 '86
12. TY Pepang
    Oct. 23-25 '87
13. TY Openg
    Sep. 08-11 '89
14. TS Maring
    Sep. 19-22 '92
15. TD Weling
    Sep. 09-11 '94

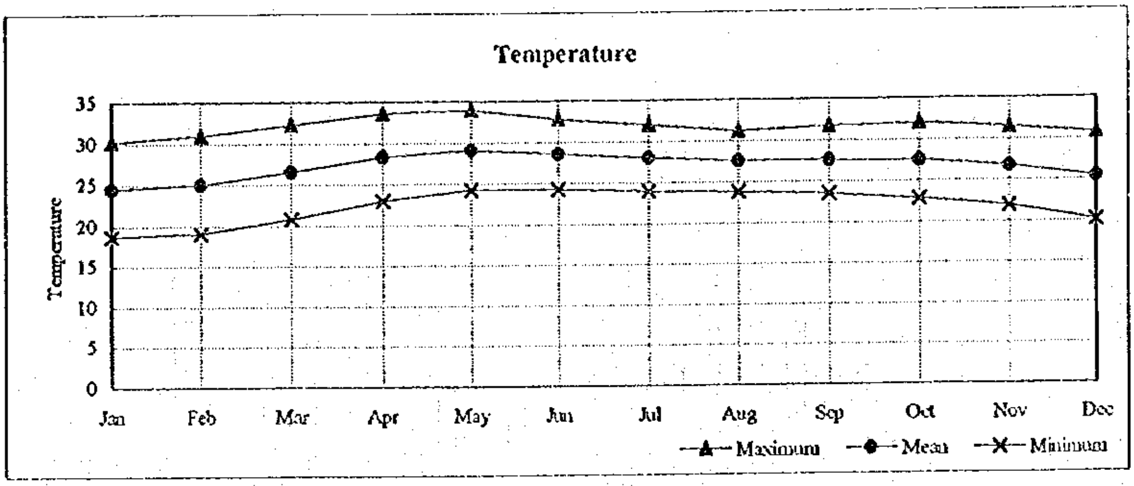
Note :
TY - Typhoon
TS - Tropical Storm
TD - Tropical Depression

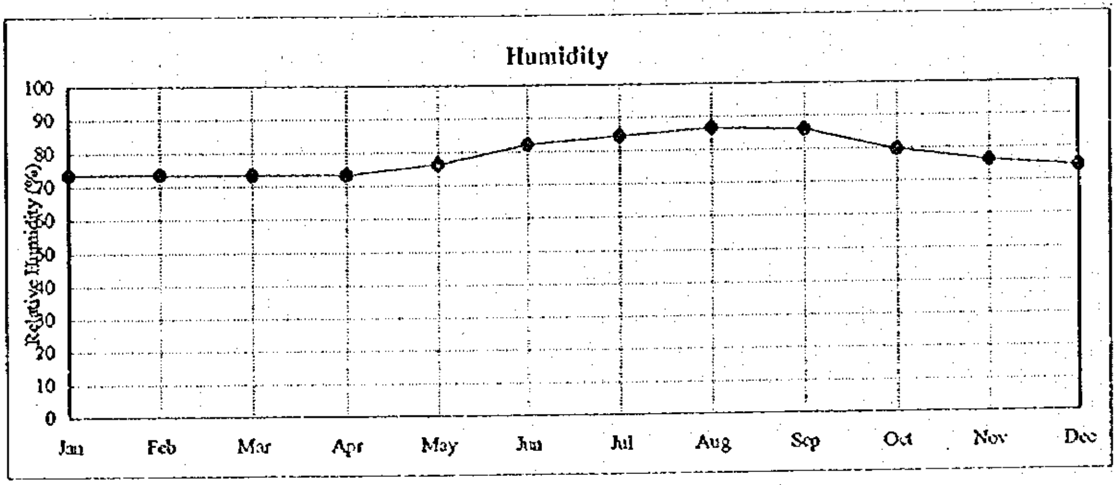
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.2.3 Tracks of Major Cyclones Affecting the Study Area



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.2.4 Monthly Rainfall in and around the Study Area

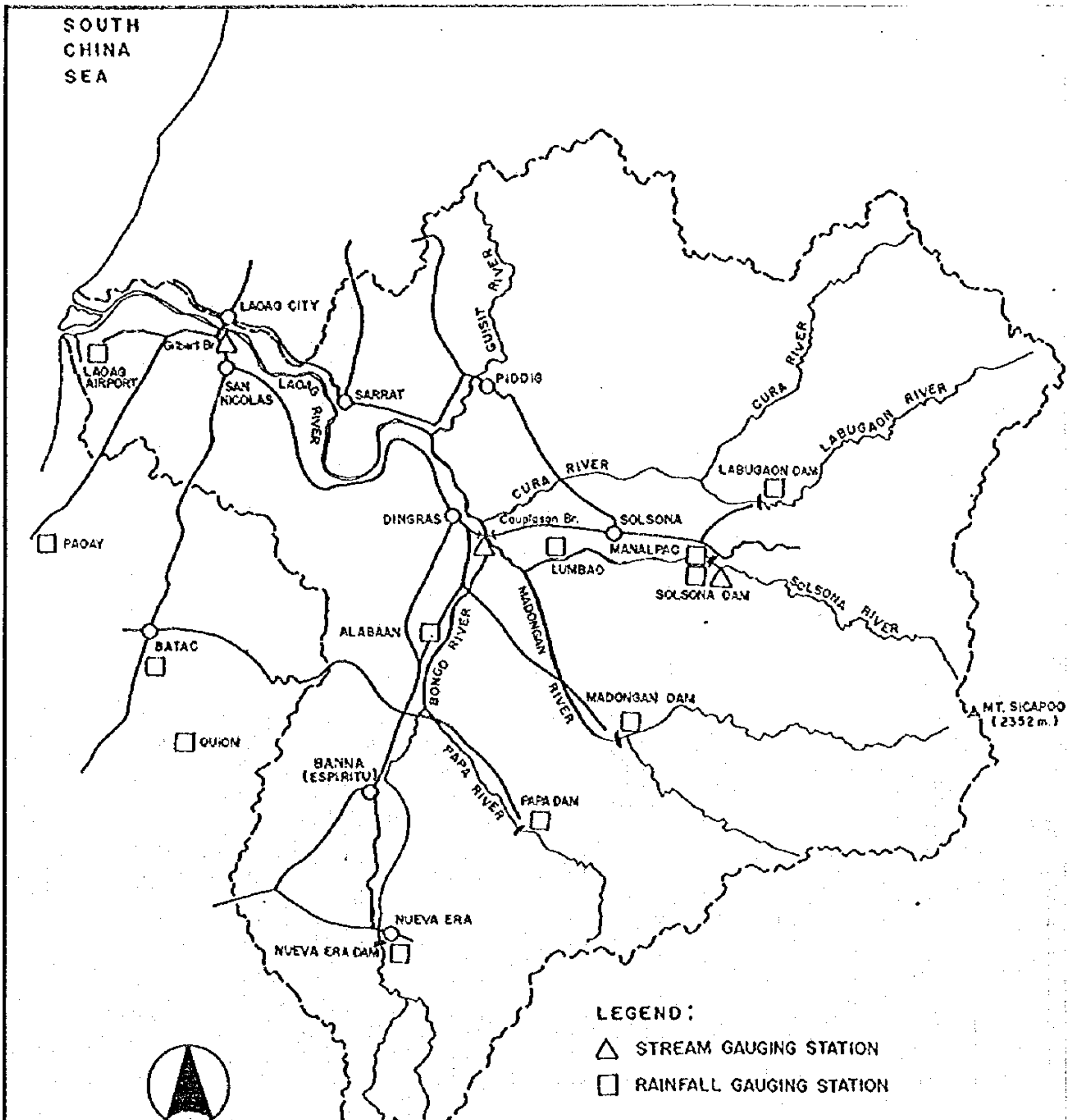






SOURCE: PAGASA

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.2.5 Monthly Rainfall, Temperature and Humidity



Rainfall Gauge

Name/Location	Elevation	Adm. Office
Laoag/Laoag Airport	5 m.	PAGASA
Batac	17 m.	PAGASA
Labugaon Dam	115 m.	NIA
Solsona Dam	113 m.	NIA
Madongan Dam	128 m.	NIA
Papa Dam	140 m.	NIA
Nueva Era Dam	110 m.	NIA
Manalpac	80 m.	NIA
Lumbad	25 m.	NIA
Alabaan	40 m.	NIA
Quiom	110 m.	NIA
Paoay	25 m.	NIA

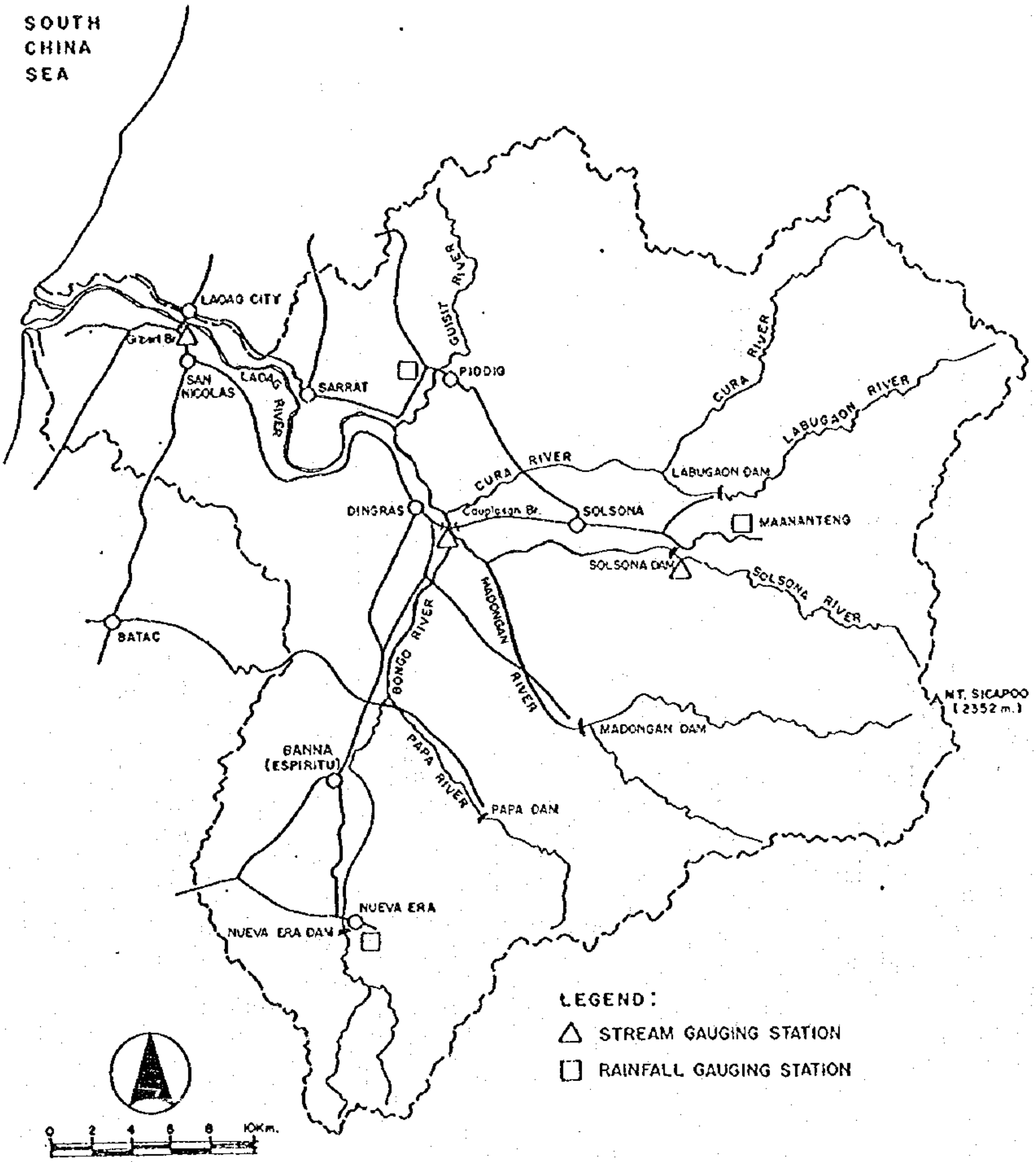
Stream Gauge

Name	Location	Adm. Office
Laoag	Gilbert Br.	DPWH
Bongo	Cauplasan Br.	DPWH
Gasgas	1 km upstream of Solsona Dam	DPWH

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. B.3.1
Location of Existing Hydrological Stations



Stream Gauge

Location	Coordinates
Gilbert Br.	N: 18° 12' 12.1" E: 120° 35' 18.7"
Cauplasan Br.	N: 18° 05' 46.6" E: 120° 42' 47.9"
Solsona Dam	N: 18° 05' 10.8" E: 120° 48' 49.9"

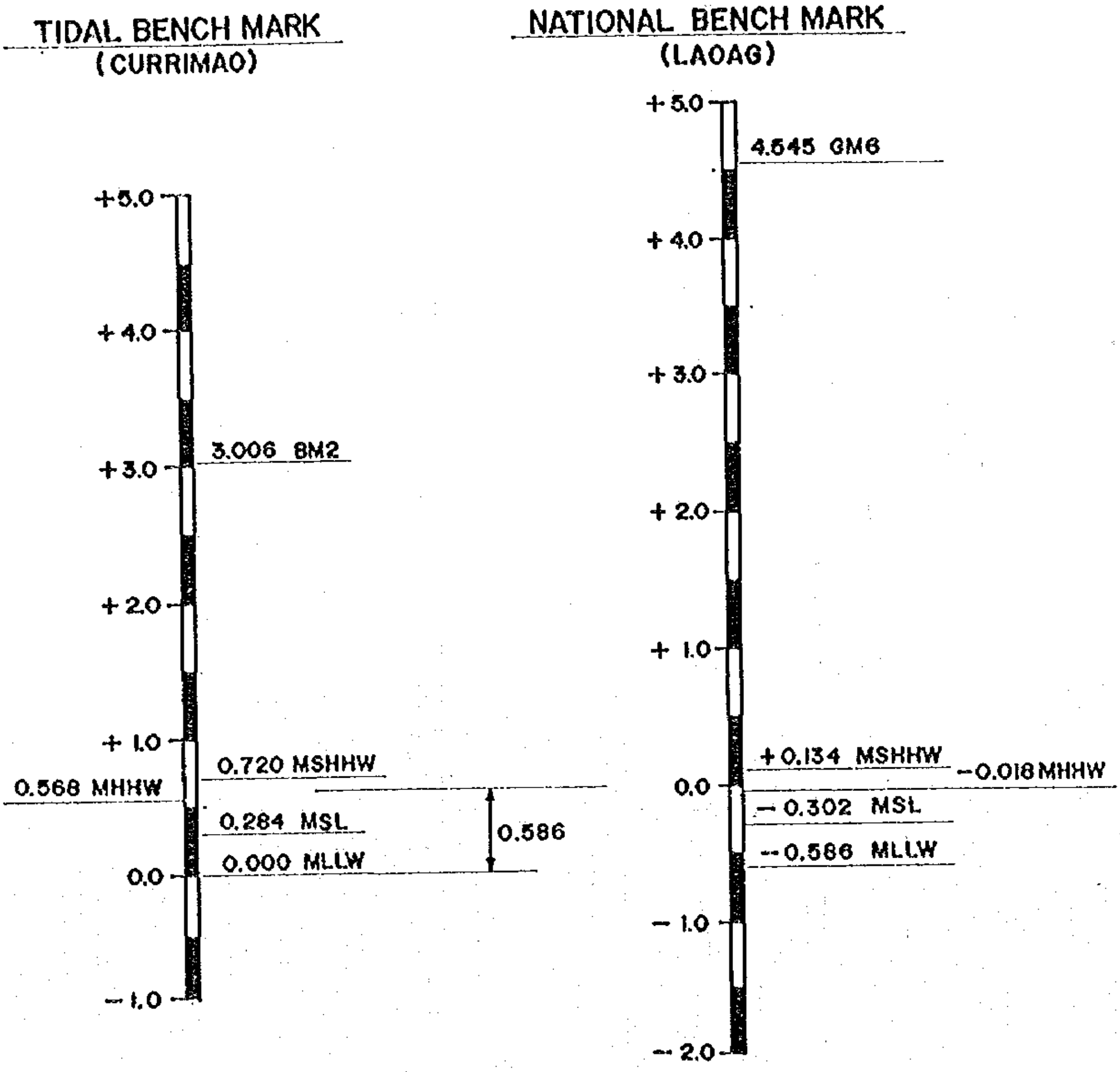
Rainfall Gauge

Name/Location	Coordinates	Elevation
Piddig/Salustiano High School	N: 18° 10' 44.3" E: 120° 43' 28.5"	25m
Solsona/ Maananteng	N: 18° 05' 53.4" E: 120° 49' 58.3"	350m
Nueva Era/ Town Hall	N: 17° 54' 56.5" E: 120° 39' 49.3"	125m

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

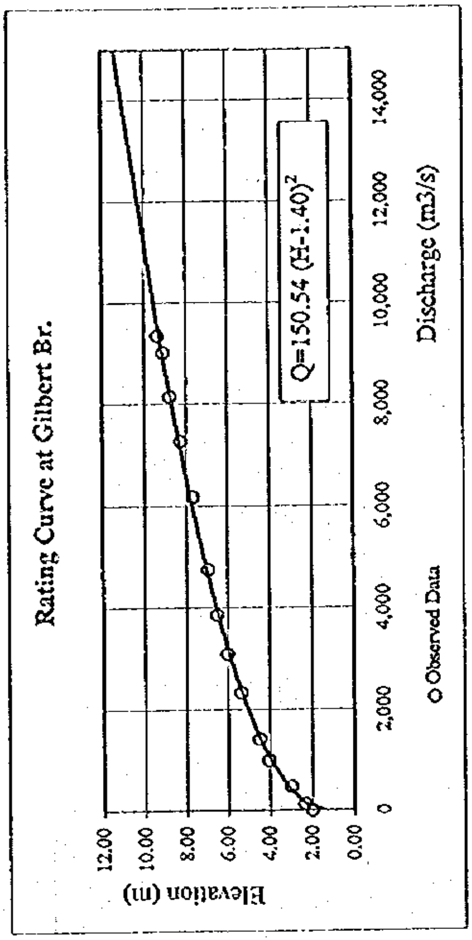
Fig. B.3.2
Location of Hydrological Stations Installed by JICA



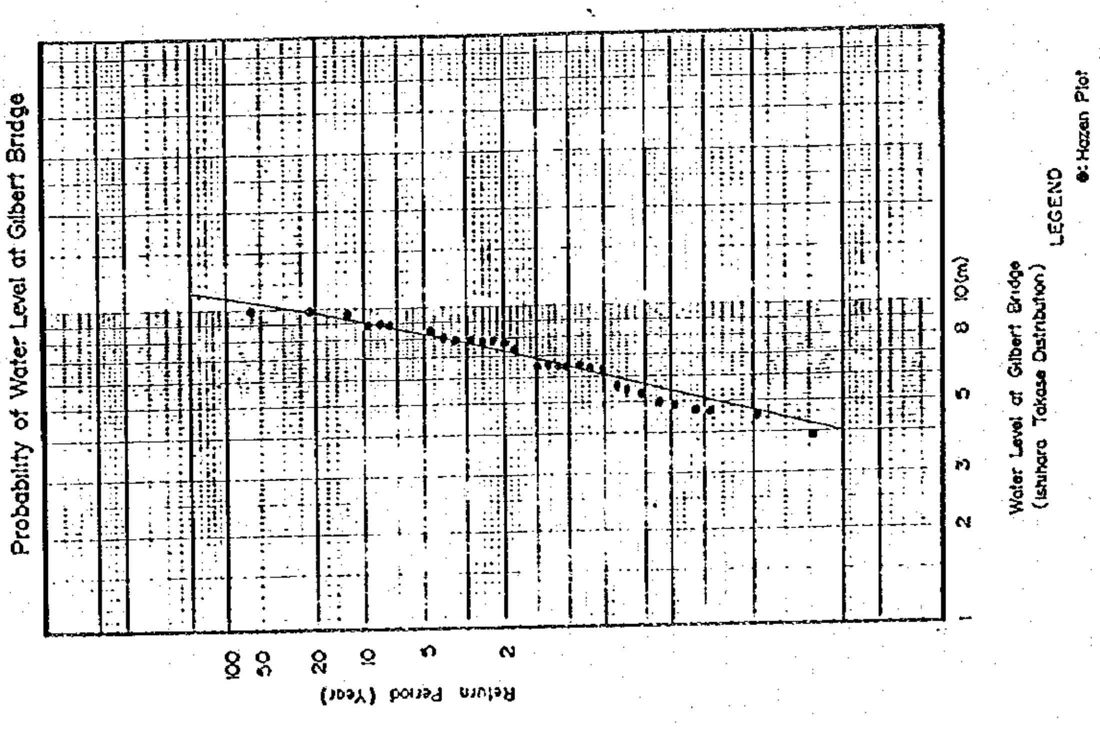
MSHHW : Mean Spring Higher High Water
MHHW : Mean Higher High Water
MSL : Mean Sea Level
MLLW : Mean Lower Low Water

Source of the Tidal Bench Mark : Predicted Tide and Current Tables
National Mapping and Resource Information Authority DENR, 1996

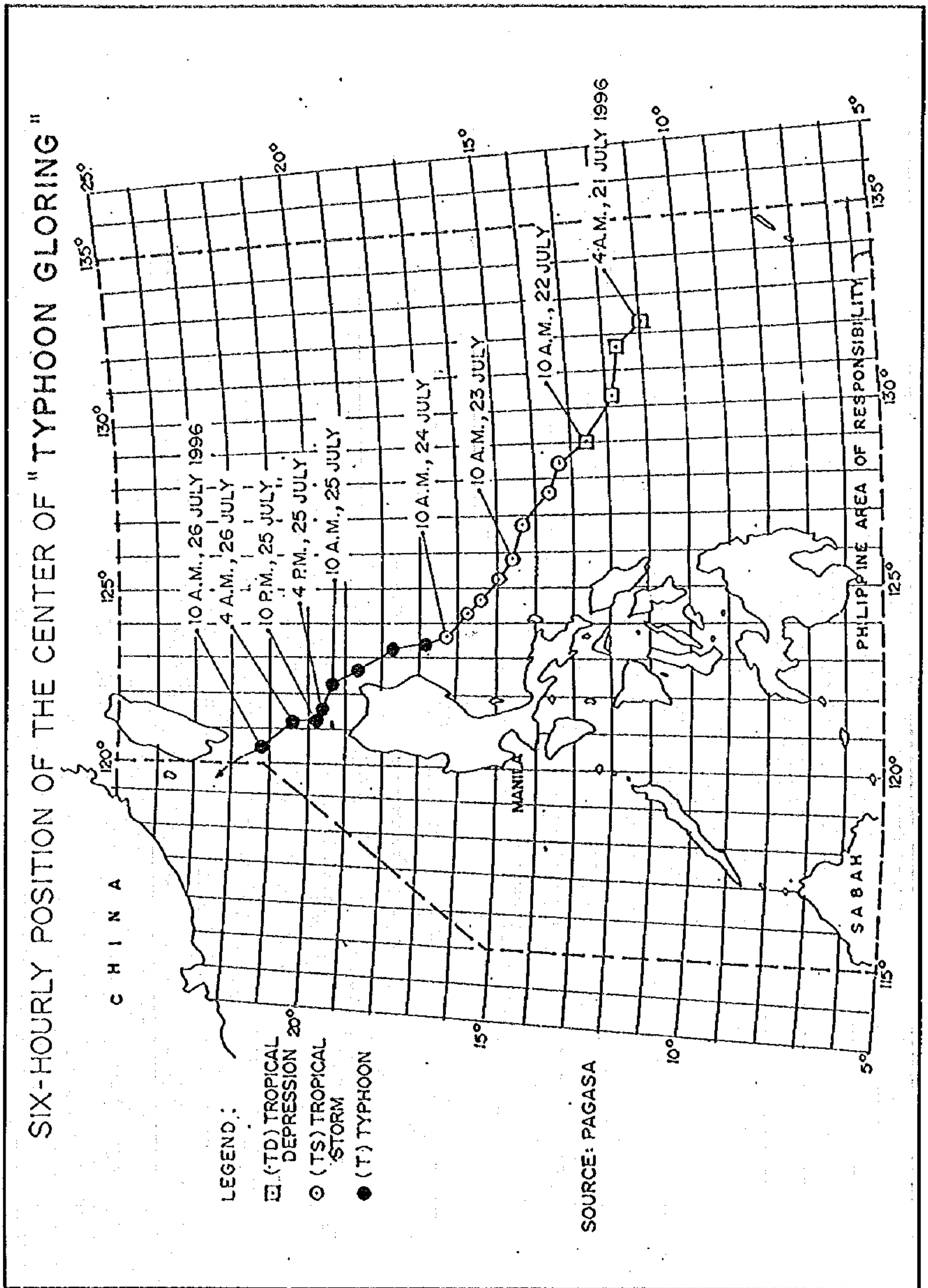
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.3.3 Relation between Tidal Bench Mark and National Bench Mark



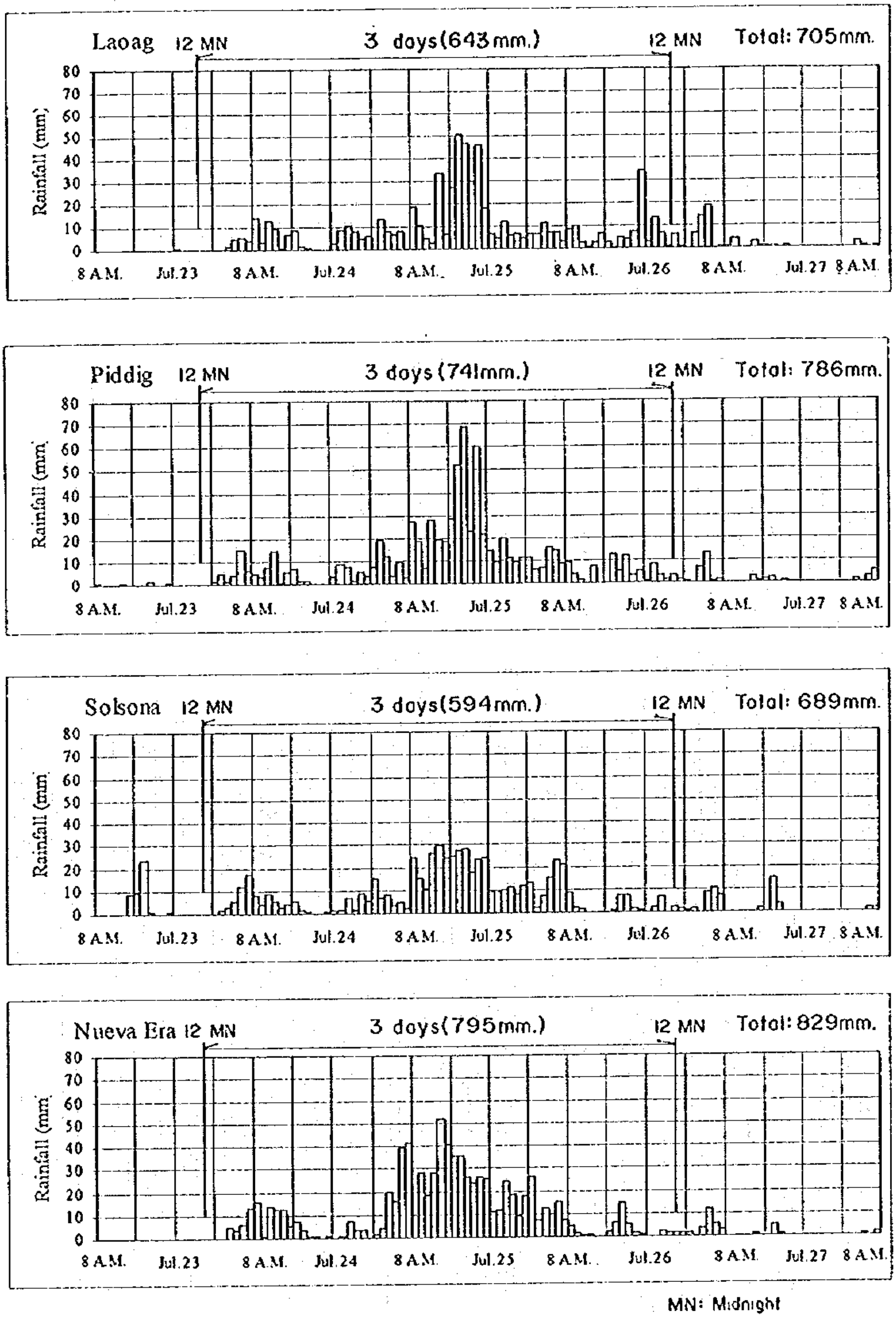
Return Period	Elevation (m)	Discharge (m3/s)
2-yr.	6.85	4,500
5-yr.	8.29	7,200
10-yr.	9.06	8,900
20-yr.	9.71	10,400
25-yr.	9.90	10,900
30-yr.	10.04	11,300
50-yr.	10.44	12,300
100-yr.	10.94	13,700



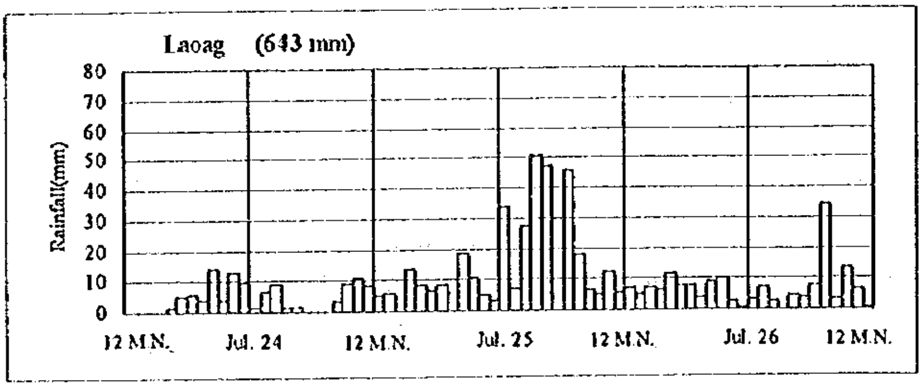
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.3.4 Probable Water Level and Rating Curve at Gilbert Br.

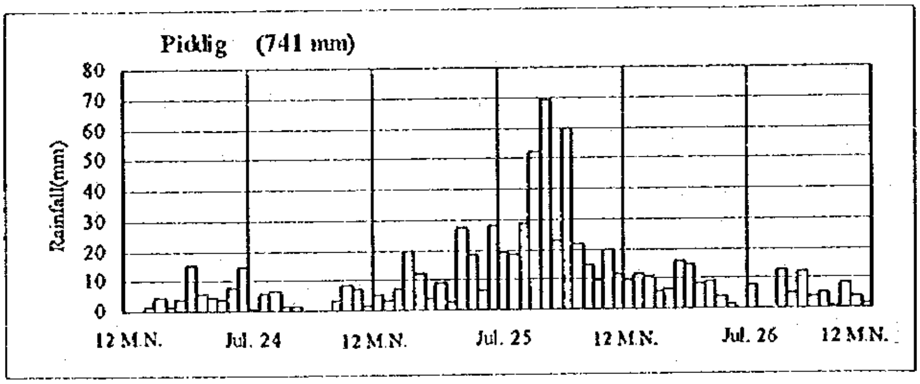


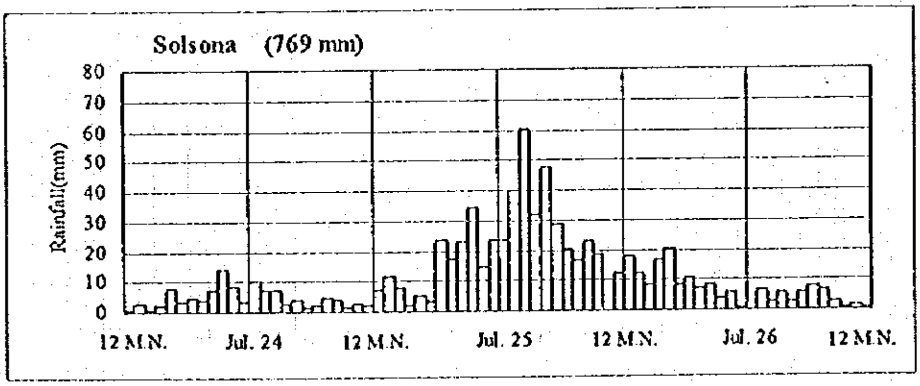
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.3.5 Track of Typhoon Gloring in 1996

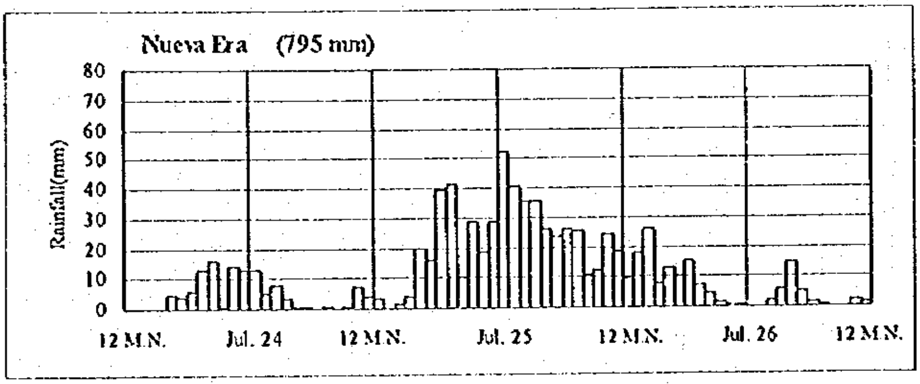


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. B.3.6
JAPAN INTERNATIONAL COOPERATION AGENCY	Hyetograph of Typhoon Gloring in 1996



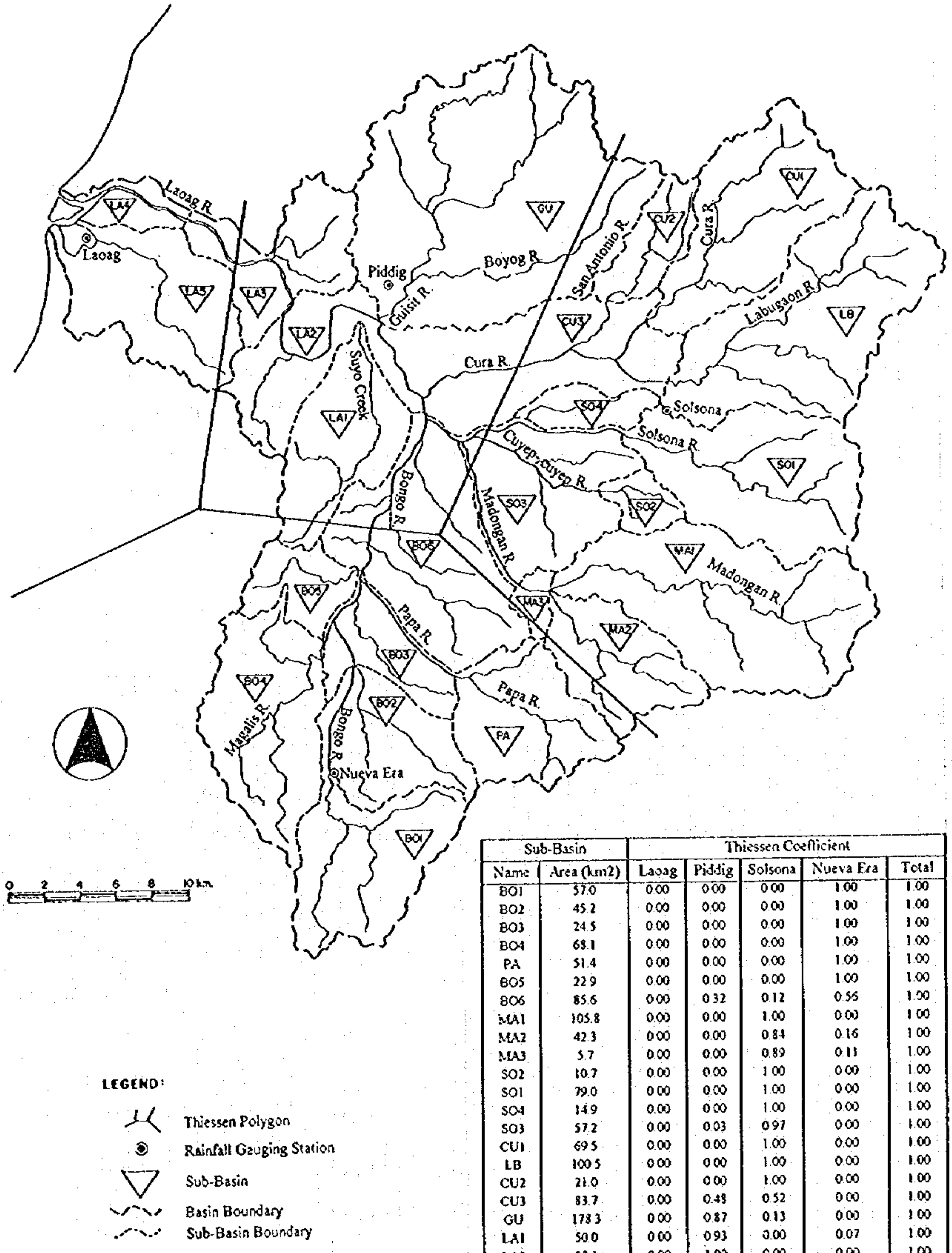






MN:Midnight

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.3.7 Model Hyetograph



Sub-Basin		Thiessen Coefficient				
Name	Area (km2)	Laoag	Piddig	Solsona	Nueva Era	Total
BO1	57.0	0.00	0.00	0.00	1.00	1.00
BO2	45.2	0.00	0.00	0.00	1.00	1.00
BO3	24.5	0.00	0.00	0.00	1.00	1.00
BO4	68.1	0.00	0.00	0.00	1.00	1.00
PA	51.4	0.00	0.00	0.00	1.00	1.00
BO5	22.9	0.00	0.00	0.00	1.00	1.00
BO6	85.6	0.00	0.32	0.12	0.56	1.00
MA1	105.8	0.00	0.00	1.00	0.00	1.00
MA2	42.3	0.00	0.00	0.84	0.16	1.00
MA3	5.7	0.00	0.00	0.89	0.11	1.00
SO2	10.7	0.00	0.00	1.00	0.00	1.00
SO1	79.0	0.00	0.00	1.00	0.00	1.00
SO4	14.9	0.00	0.00	1.00	0.00	1.00
SO3	57.2	0.00	0.03	0.97	0.00	1.00
CU1	69.5	0.00	0.00	1.00	0.00	1.00
LB	100.5	0.00	0.00	1.00	0.00	1.00
CU2	21.0	0.00	0.00	1.00	0.00	1.00
CU3	83.7	0.00	0.48	0.52	0.00	1.00
GU	178.3	0.00	0.87	0.13	0.00	1.00
LA1	50.0	0.00	0.93	0.00	0.07	1.00
LA2	38.1	0.00	1.00	0.00	0.00	1.00
LA3	43.0	0.16	0.84	0.00	0.00	1.00
LA4	15.1	1.00	0.00	0.00	0.00	1.00
LA5	62.6	0.95	0.05	0.00	0.00	1.00

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

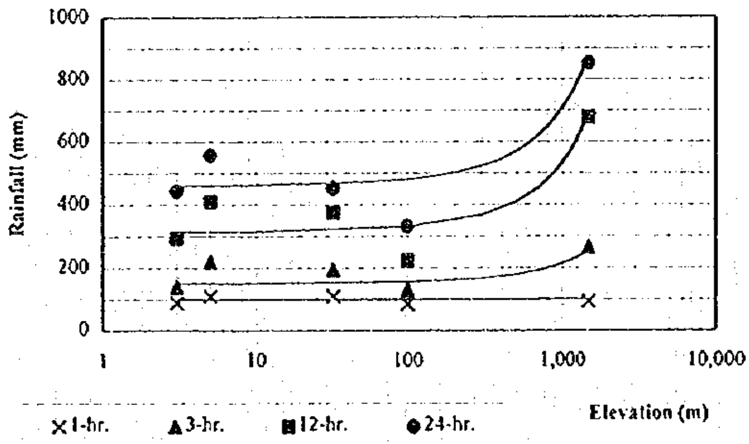
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. B.3.8
Thiessen Polygon and Coefficient

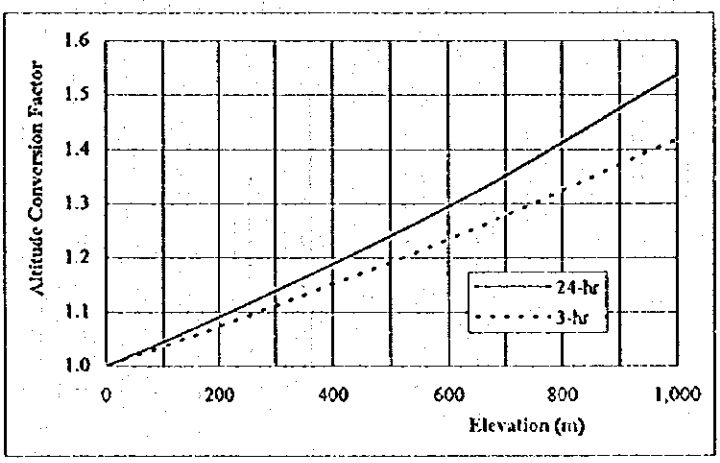
Relation between Rainfall and Elevation

Rainfall Station		Rainfall of various duration (mm)			
Name	Elevation	1-hr.	3-hr.	12-hr.	24-hr.
Dagupan	3 m	88.3	139.9	294.3	442.7
Laoag	5 m	109.8	219.5	409.7	557.5
Vigan	33 m	109.5	193.7	376.3	452.6
Sta.Cruz	100 m	84.0	129.0	222.2	330.6
Baguio	1500 m	92.9	245.4	678.1	852.4

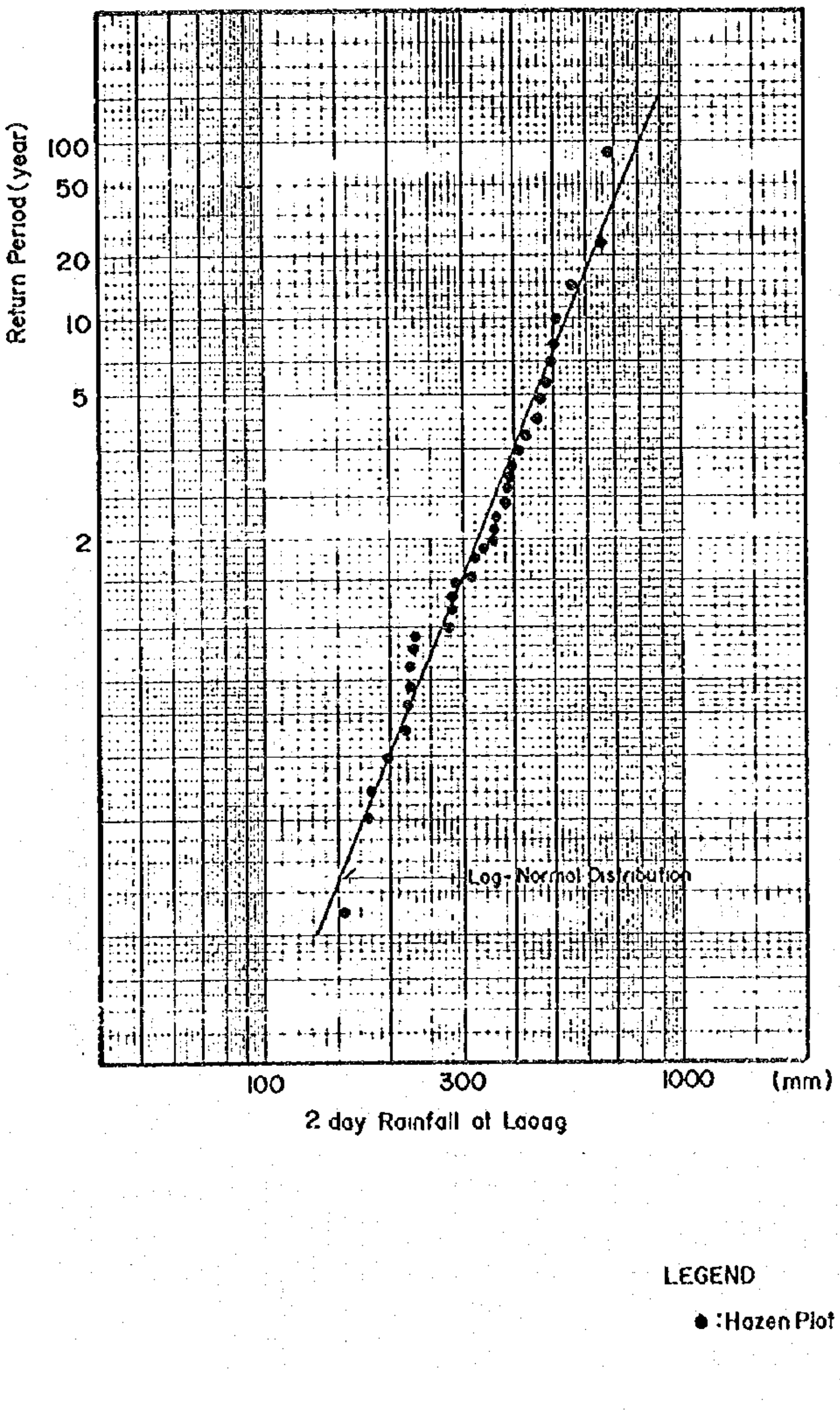
Source : PAGASA



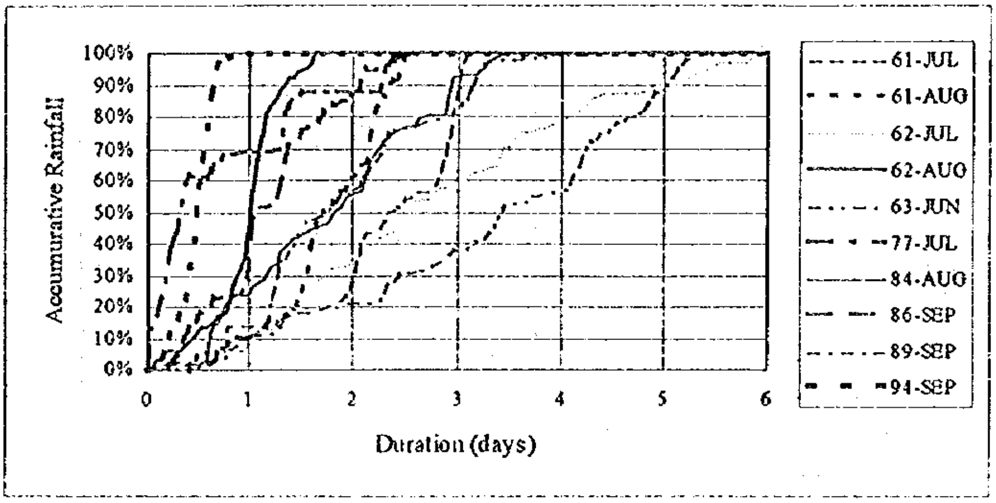
Altitude Conversion Factor



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. B.3.9 Altitude Conversion Factor
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.3.10 Probable 2-day Rainfall at Laoag Station



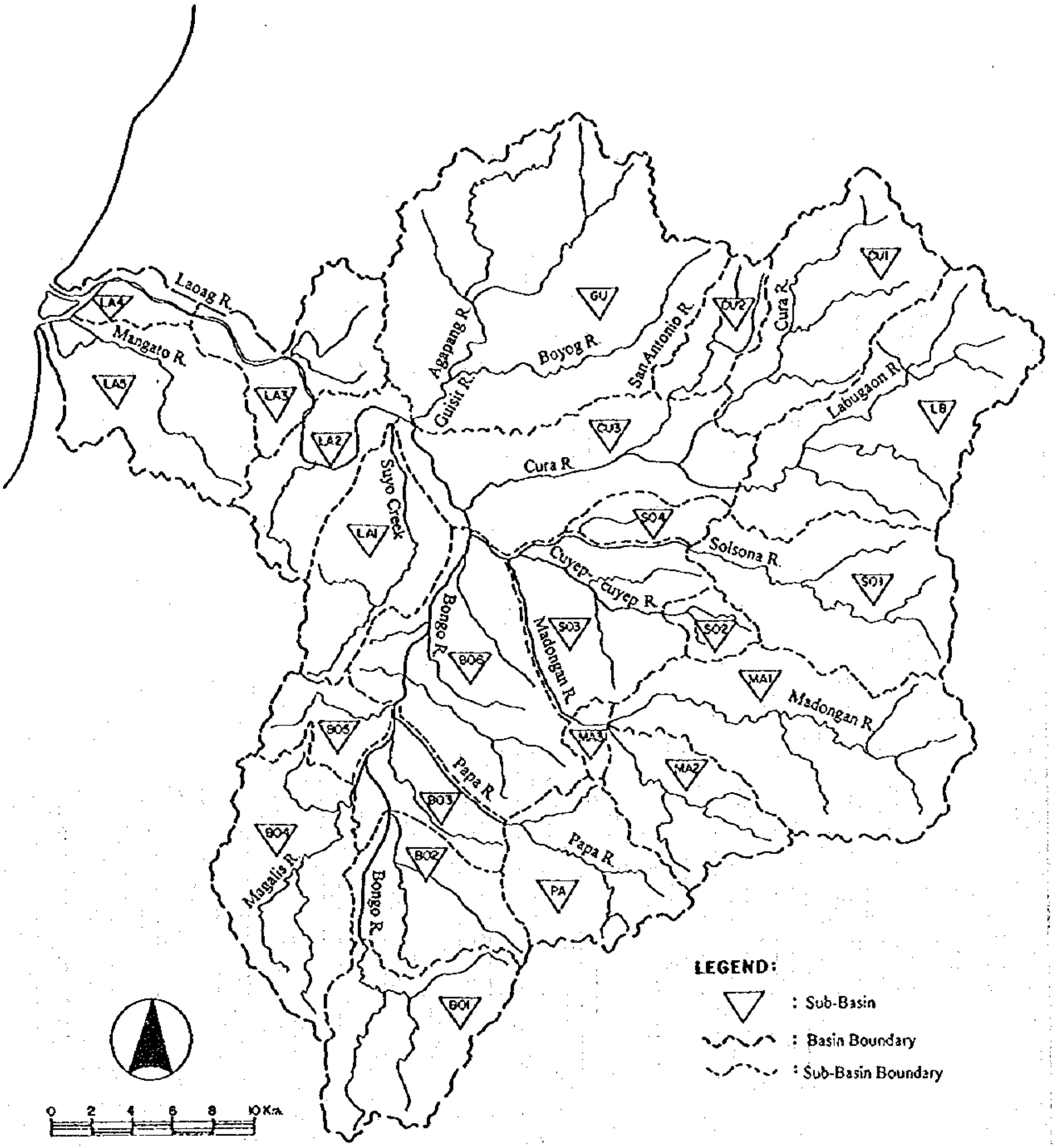
	Record of Cyclone			Rainfall Duration [1]	Water Level / Discharge [2] at Gilbert Br.	
	Date		Name		WL (m)	Dis. (m^3/s)
1	1961	Jul 10 - 14	-	2 days	-	-
2	1961	Aug 22 - 25	Lorna	2 days	7.78	6,200
3	1962	Jul 18 - 23	Kate	4 days	-	-
4	1962	Aug 29 - 31	Wanda	2 days	9.83	10,800
5	1963	Jun 04 - 09	Bebeng	4 days	-	-
6	1977	Jul 23 - 25	Goring	2 days	8.88	8,500
7	1984	Aug 27 - 30	Maring	2 days	-	-
8	1986	Aug30-Sep3	Miding	2 days	9.42	9,700
9	1989	Sep 08 - 11	Openg	3 days	5.25	-
10	1994	Sep 09 - 11	Weling	1 day	7.60	-

[1] : Duration of rainfall is a 80 % of the total rainfall duration
[2] : Elevation of Water level is converted to JICA datums
- : Not available

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. B.3.11
Storm Rainfall Duration

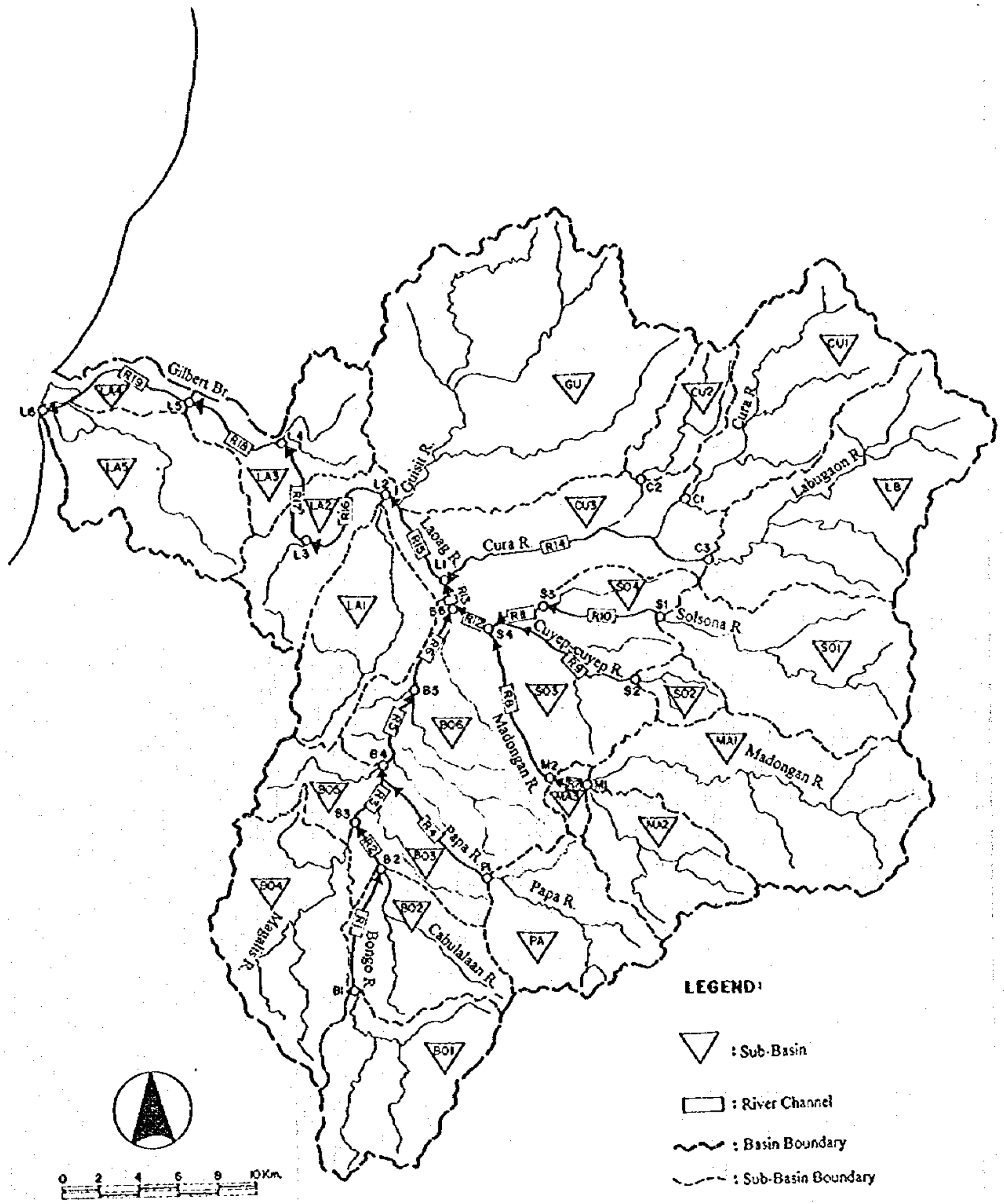


Sub-Basin	Catchment Area (km²)	Sub-Basin	Catchment Area (km²)	Sub-Basin	Catchment Area (km²)
BO1	57.0	MA2	42.3	CU2	21.0
BO2	45.2	MA3	5.7	CU3	83.7
BO3	24.5	SO2	10.7	GU	178.3
BO4	68.1	SO1	79.0	LA1	50.0
PA	51.4	SO4	14.9	LA2	38.1
BO5	22.9	SO3	57.2	LA3	43.0
BO6	85.6	CU1	69.5	LA4	15.1
MA1	105.8	LB	100.5	LA5	62.6
Total					1332.1

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. B.4.1
Division of Laoag River Basin



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. B.4.2
River System Model for Runoff Calculation

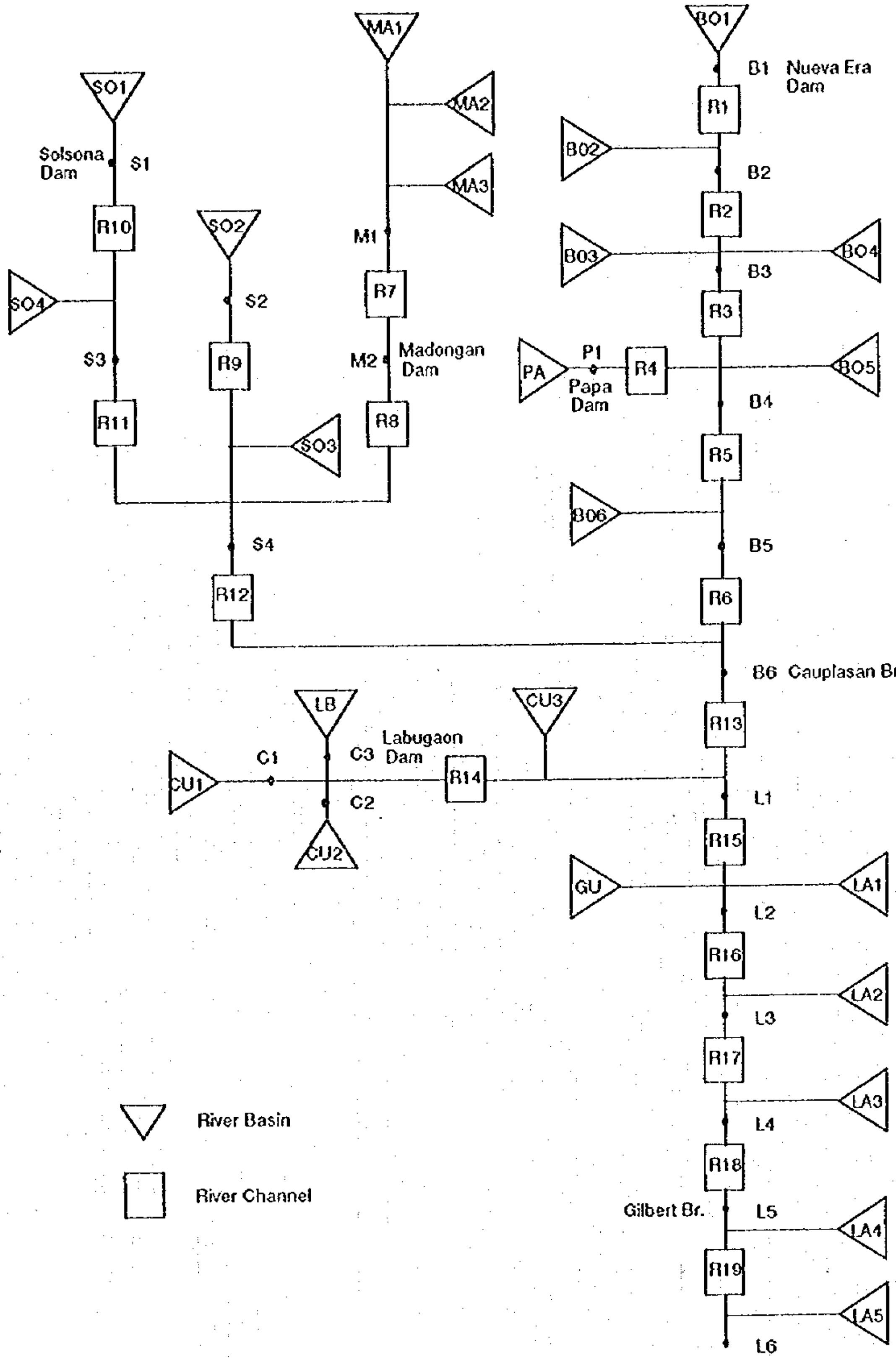
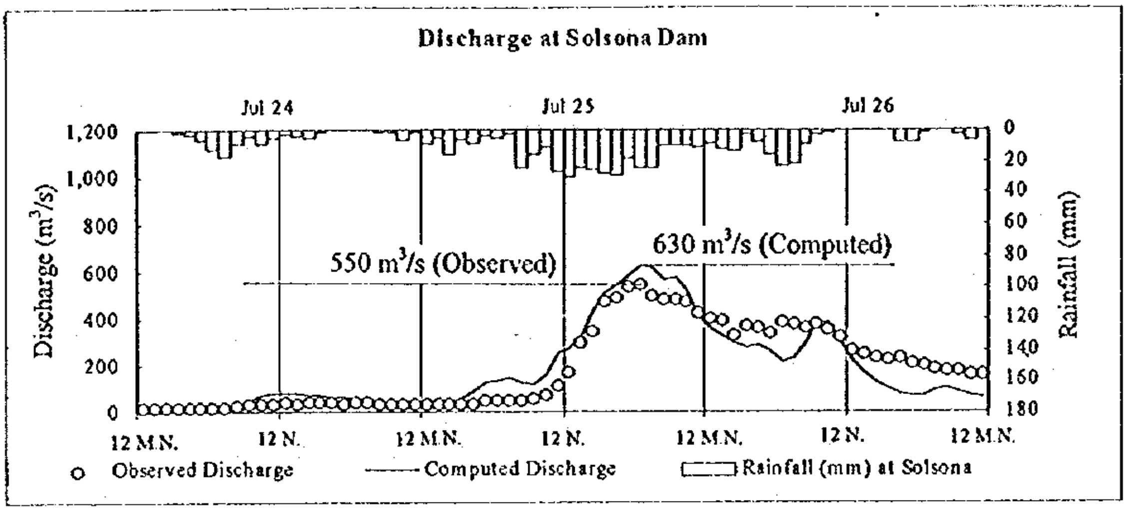
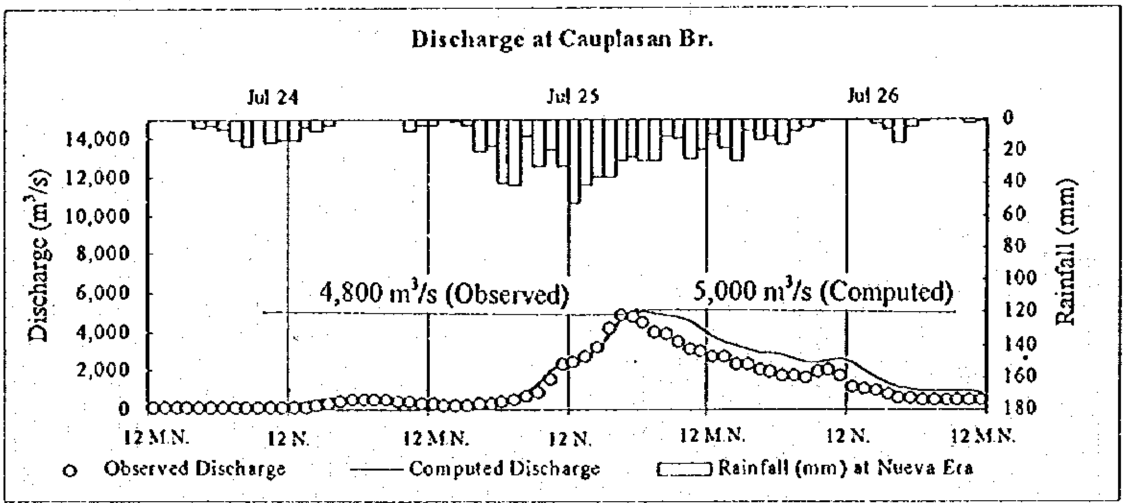
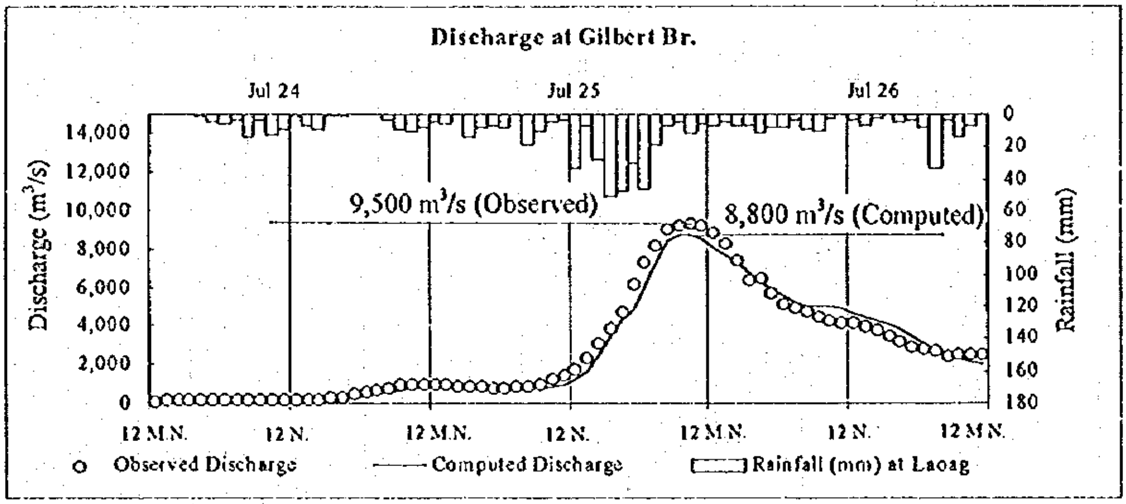


Fig. B.4.3
River System Diagram for Runoff Calculation





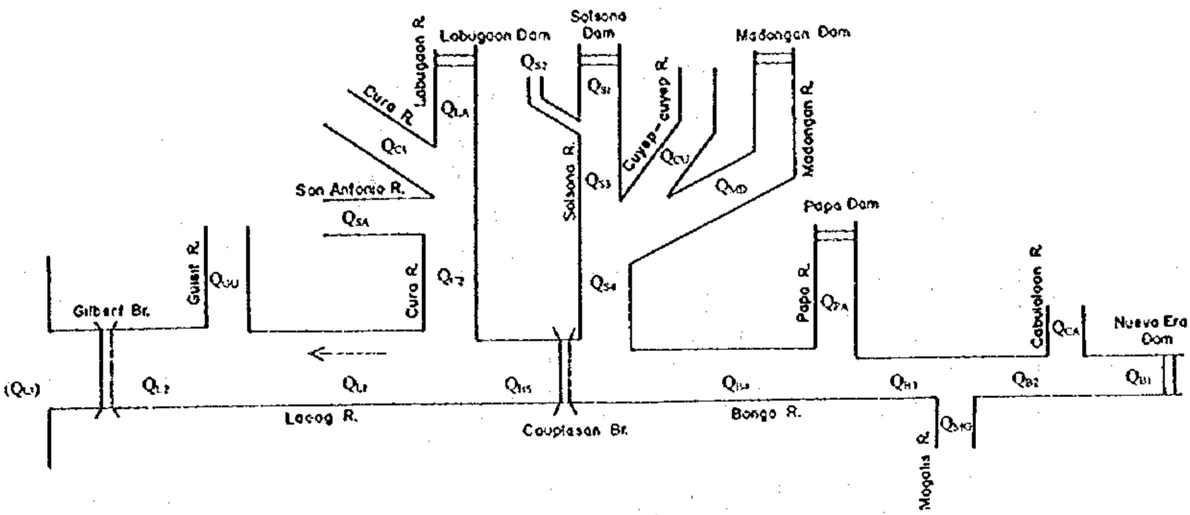


M.N.: Midnight
N. : Noon

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. B.4.4
Comparison of Observed and Computed Hydrographs on Typhoon Gloring

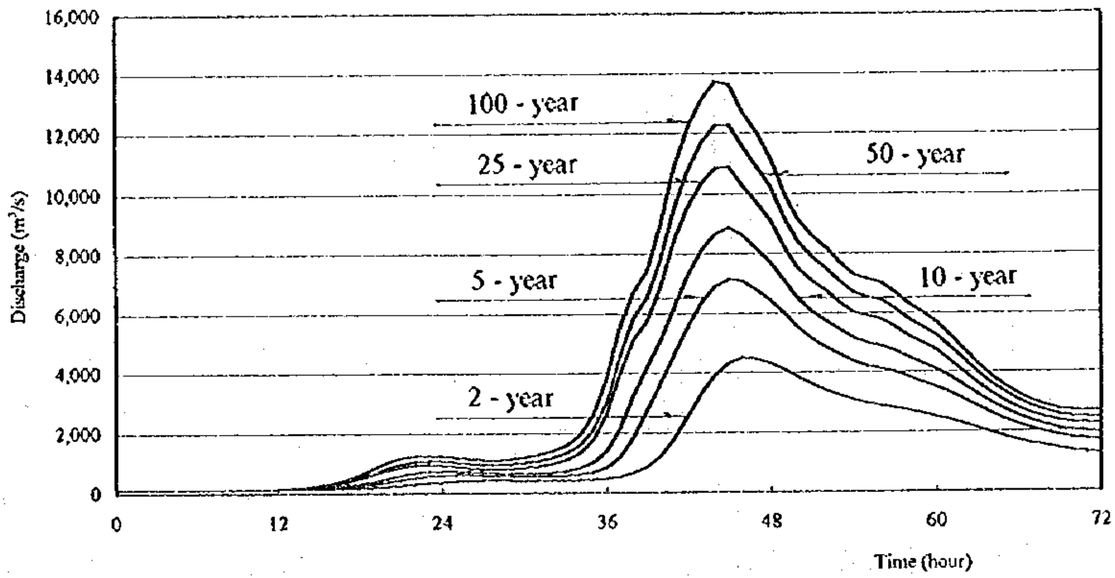


	Probable Flood Discharge (m^3/s)					
	2-year	5-year	10-year	25-year	50-year	100-year
Q_{B1}	340	510	620	750	830	920
Q_{CA}	190	300	360	440	490	540
Q_{B2}	520	790	960	1,160	1,300	1,440
Q_{MO}	280	450	540	660	740	820
Q_{B3}	860	1,340	1,640	2,000	2,240	2,480
Q_{PA}	310	470	570	690	770	850
Q_{B4}	1,380	2,150	2,630	3,220	3,620	4,020
Q_{MD}	880	1,320	1,610	1,970	2,220	2,470
Q_{S1}	460	690	840	1,030	1,150	1,280
Q_{S2}	40	70	90	120	130	150
Q_{S3}	490	760	920	1,120	1,250	1,390
Q_{CU}	170	290	360	460	530	590
Q_{S4}	1,500	2,330	2,860	3,490	3,920	4,360
Q_{B5}	2,810	4,390	5,400	6,500	7,000	8,200
Q_{C1}	380	580	700	850	960	1,060
Q_{LA}	560	850	1,020	1,260	1,410	1,570
Q_{SA}	130	190	230	280	310	350
Q_{C2}	1,050	1,580	1,930	2,360	2,650	2,940
Q_{L1}	3,760	5,800	7,100	8,700	9,800	10,900
Q_{OU}	470	840	1,080	1,390	1,590	1,800
Q_{L2}	4,500	7,200	8,900	10,900	12,300	13,700
Q_{L3}	4,580	7,300	9,100	11,200	12,700	14,200

* : (Q_{L3}) is flood discharge at river mouth

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.4.5 Probable Flood Discharge

Probable Flood Hydrograph at Gilbert Bridge



Probable Maximum Flood Discharge at Gilbert Bridge

Return Period	Water Level	Flood Dischrge
2 - year	6.85 m	4,500 m^3/s
5 - year	8.29 m	7,200 m^3/s
10 - year	9.06 m	8,900 m^3/s
25 - year	9.90 m	10,900 m^3/s
50 - year	10.44 m	12,300 m^3/s
100 - year	10.94 m	13,700 m^3/s

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

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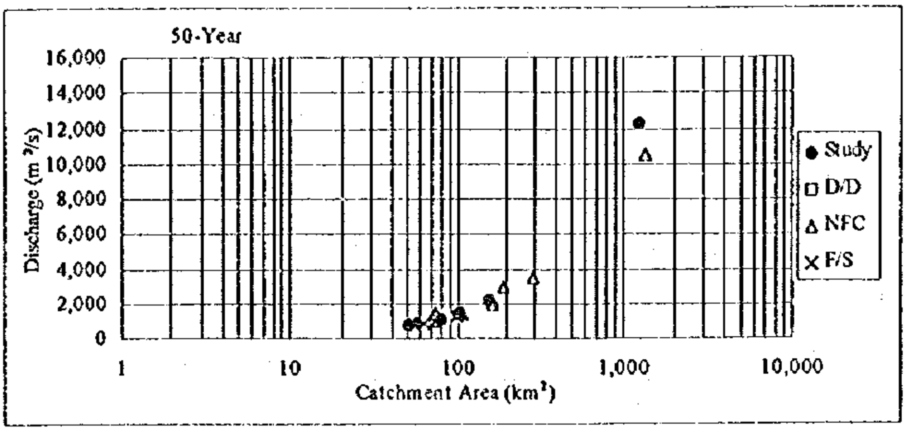
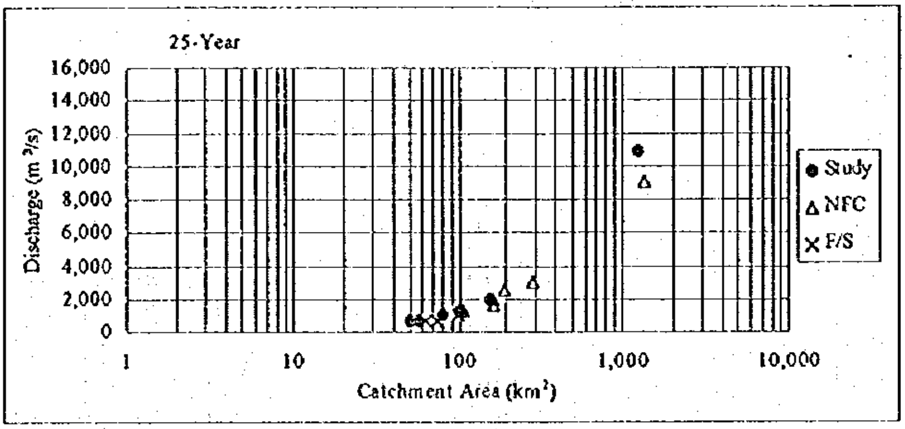
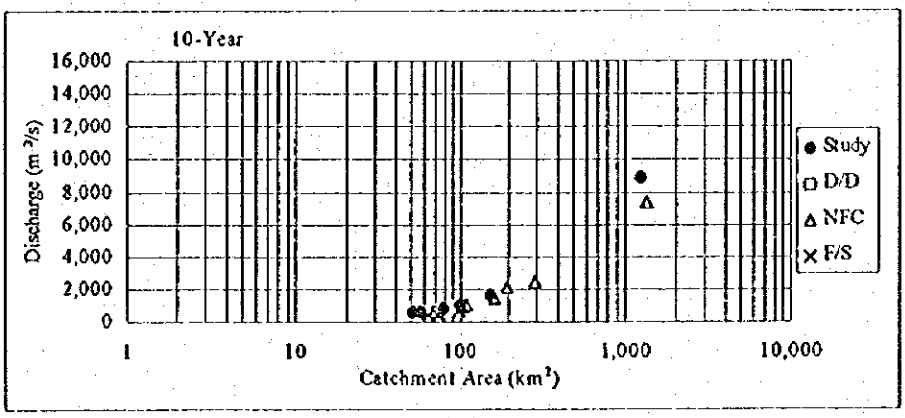
Fig. B.4.6
Probable Flood Hydrograph at Gilbert Br.

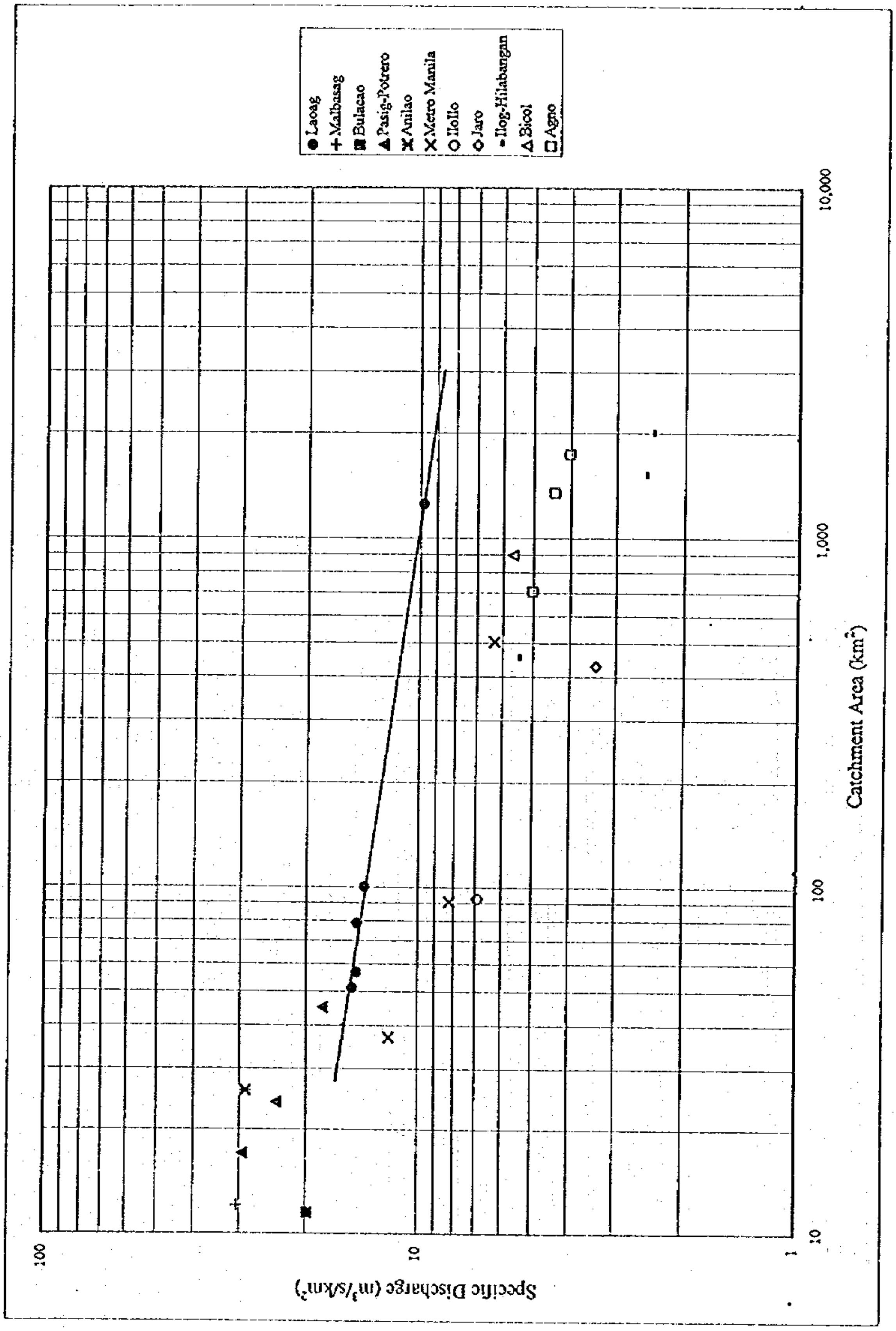




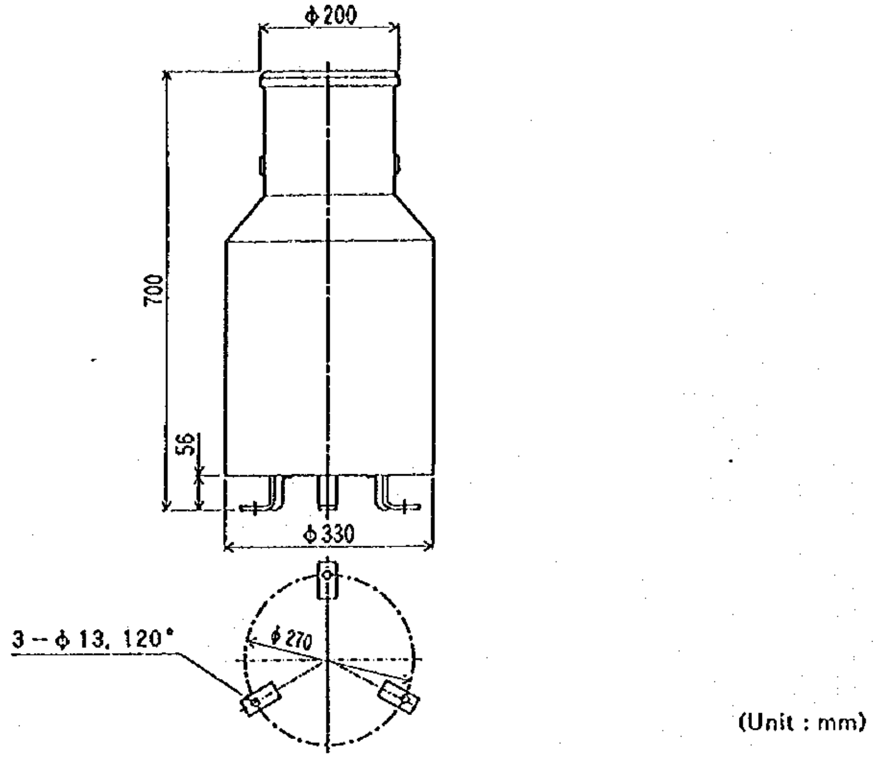


1) Study : The Study on Sabo and Flood Control in The Laoag River Basin, JICA
2) D/D : Detailed Design Report on Ilocos Norte Irrigation Project, NIA, 1981
3) NFC : Nationwide Flood Control Plan and River Dredging Program, DPWH, 1982
4) F/S : Feasibility Study on the Tina-Gasgas-Cura Impounding Reservoir Project At Solsona, NIA, 1983

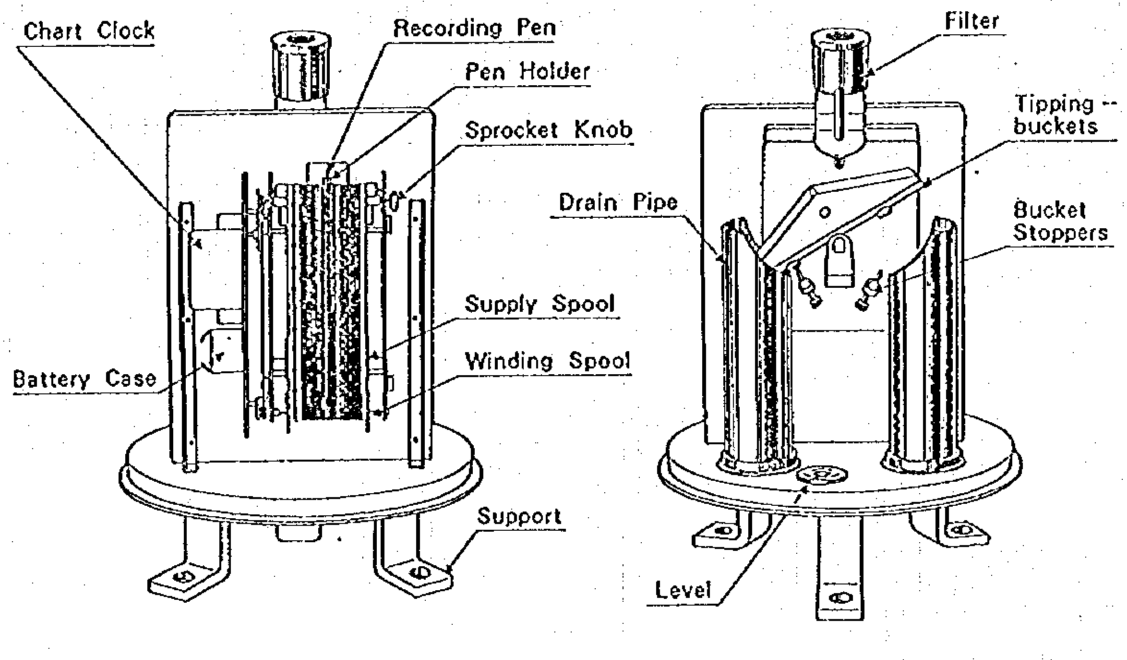
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.4.7 Comparison of Flood Discharges with Other Studies



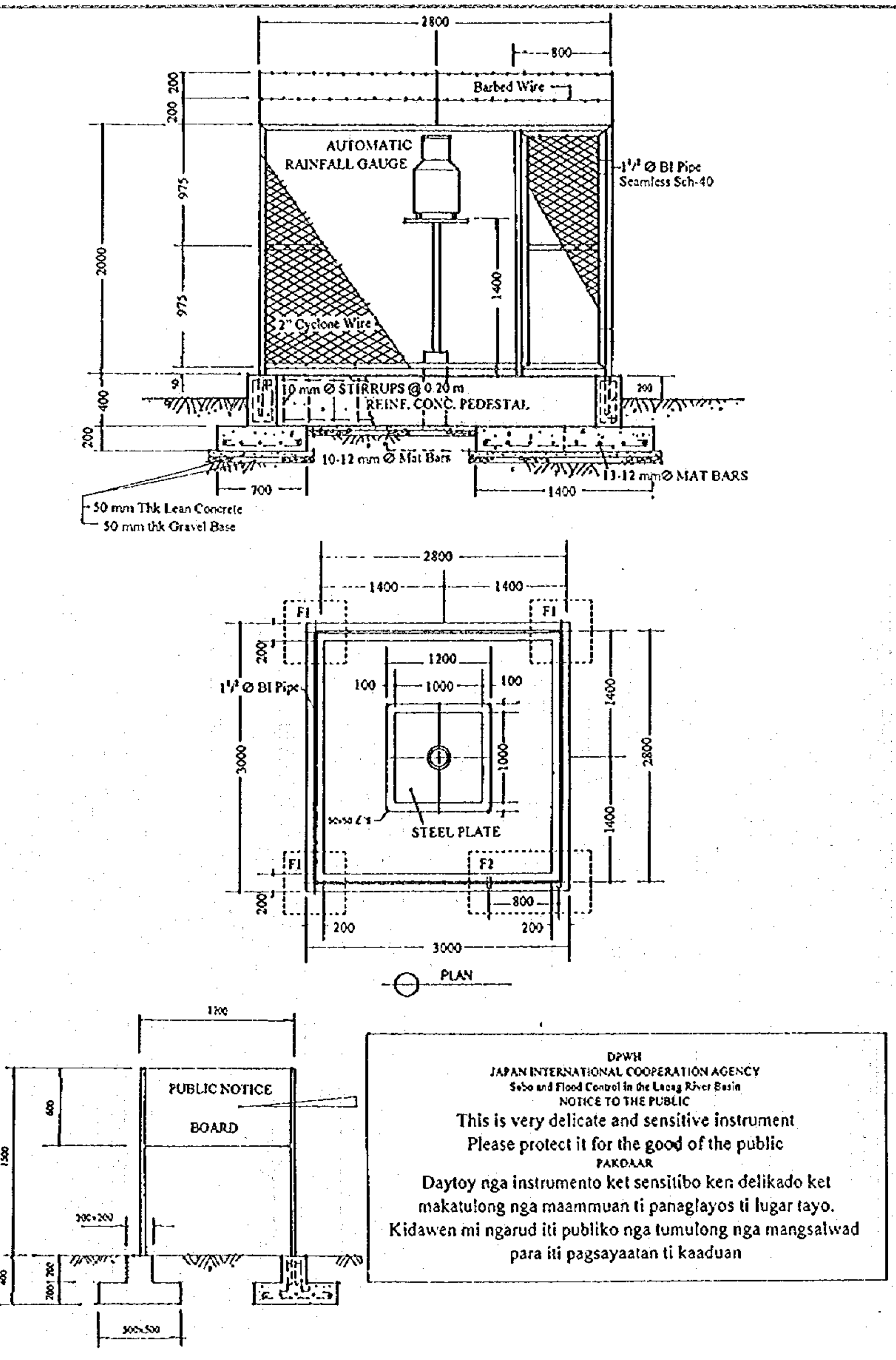
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. B.4.8
JAPAN INTERNATIONAL COOPERATION AGENCY	Comparison of Specific Discharges with Other River Basins



Model B-432-01



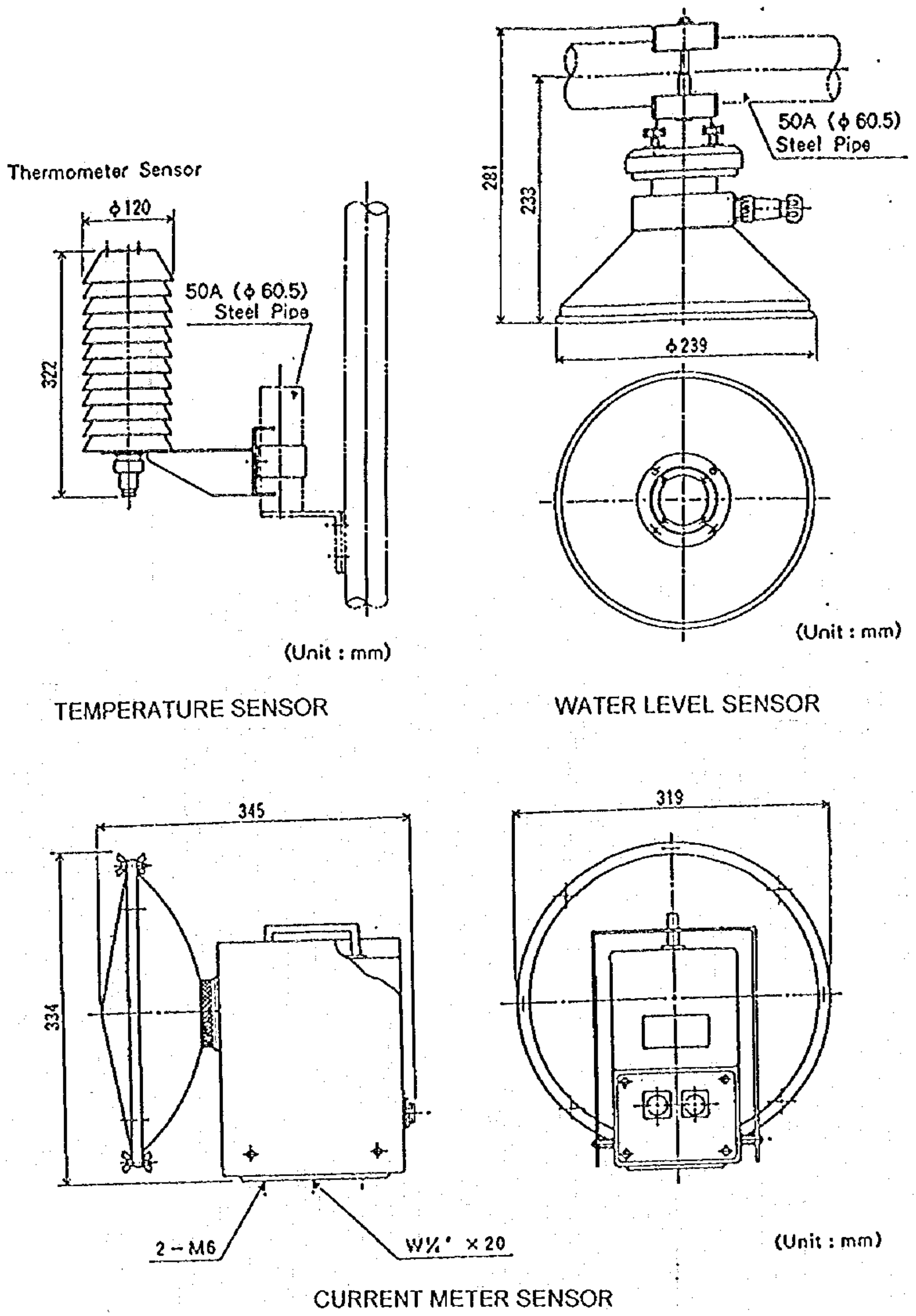
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.5.1 Automatic Rainfall Gauge



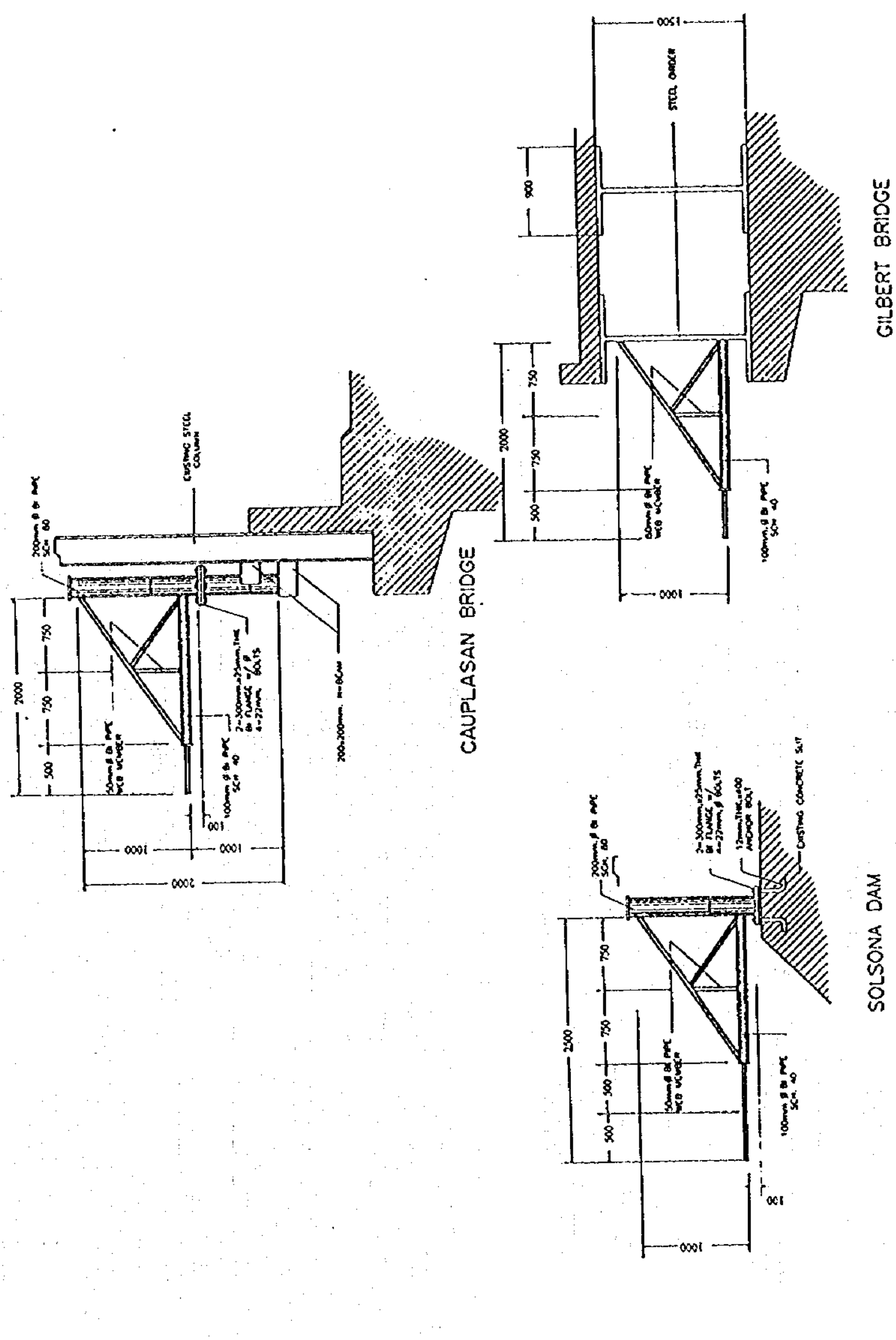
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. B.5.2
Structural Layout of Rainfall Station



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.5.3 Details of Sensors for Stream Flow Gauge



THE STUDY ON SABO AND FLOOD CONTROL
IN THE LAOAG RIVER BASIN

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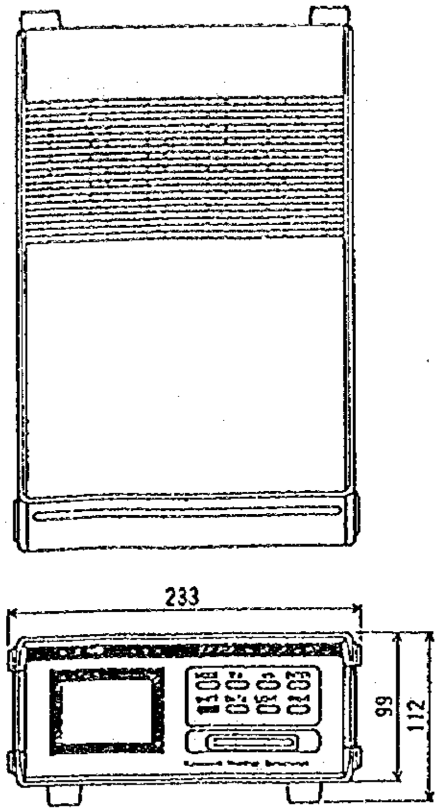
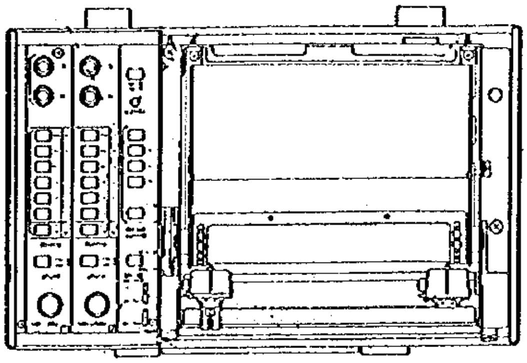
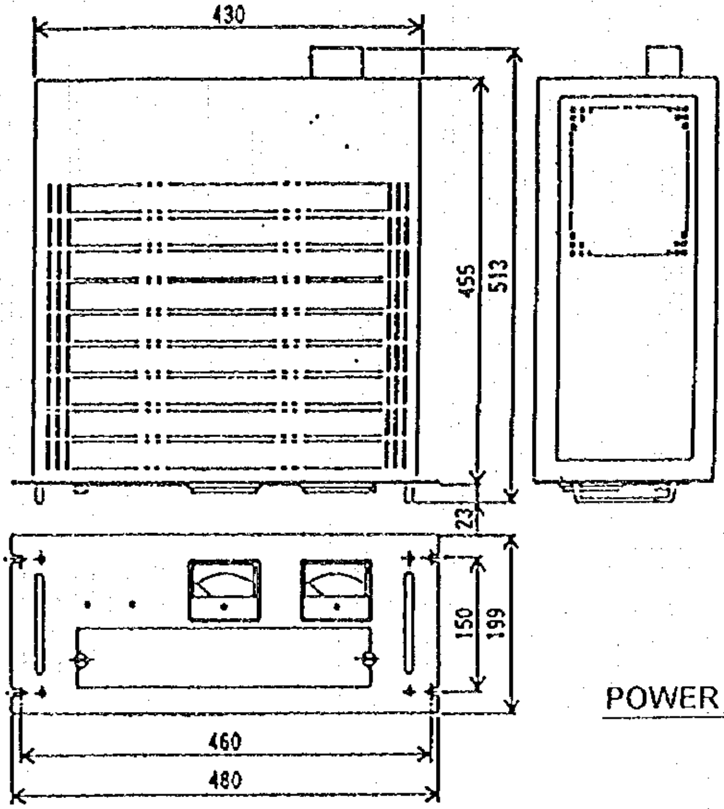
Fig. B.5.4
Details of Support of Censors for Stream Flow Gauge



CURRENT METER WITH MEMORY CARD LOGGER

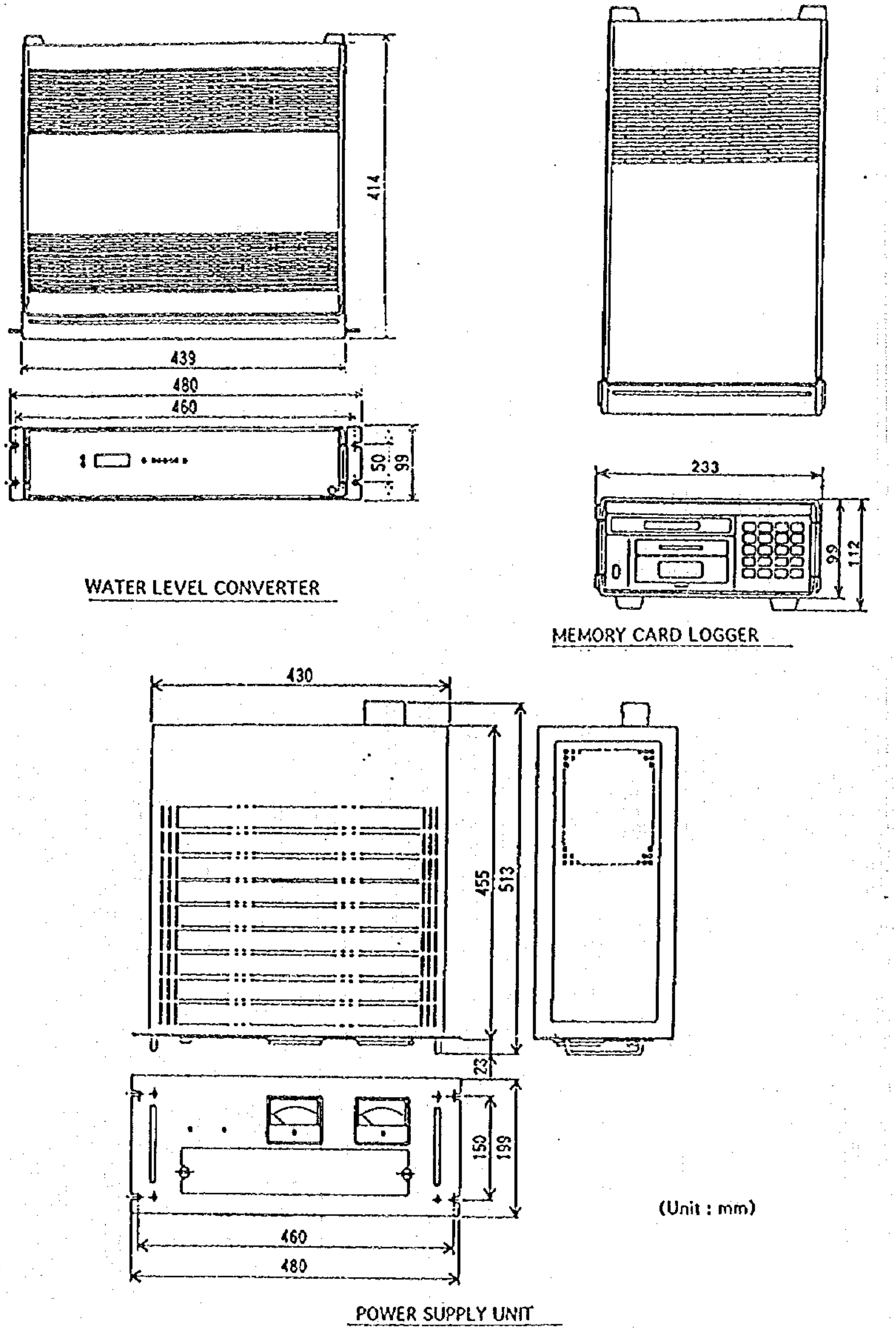


PORTABLE RECORDER

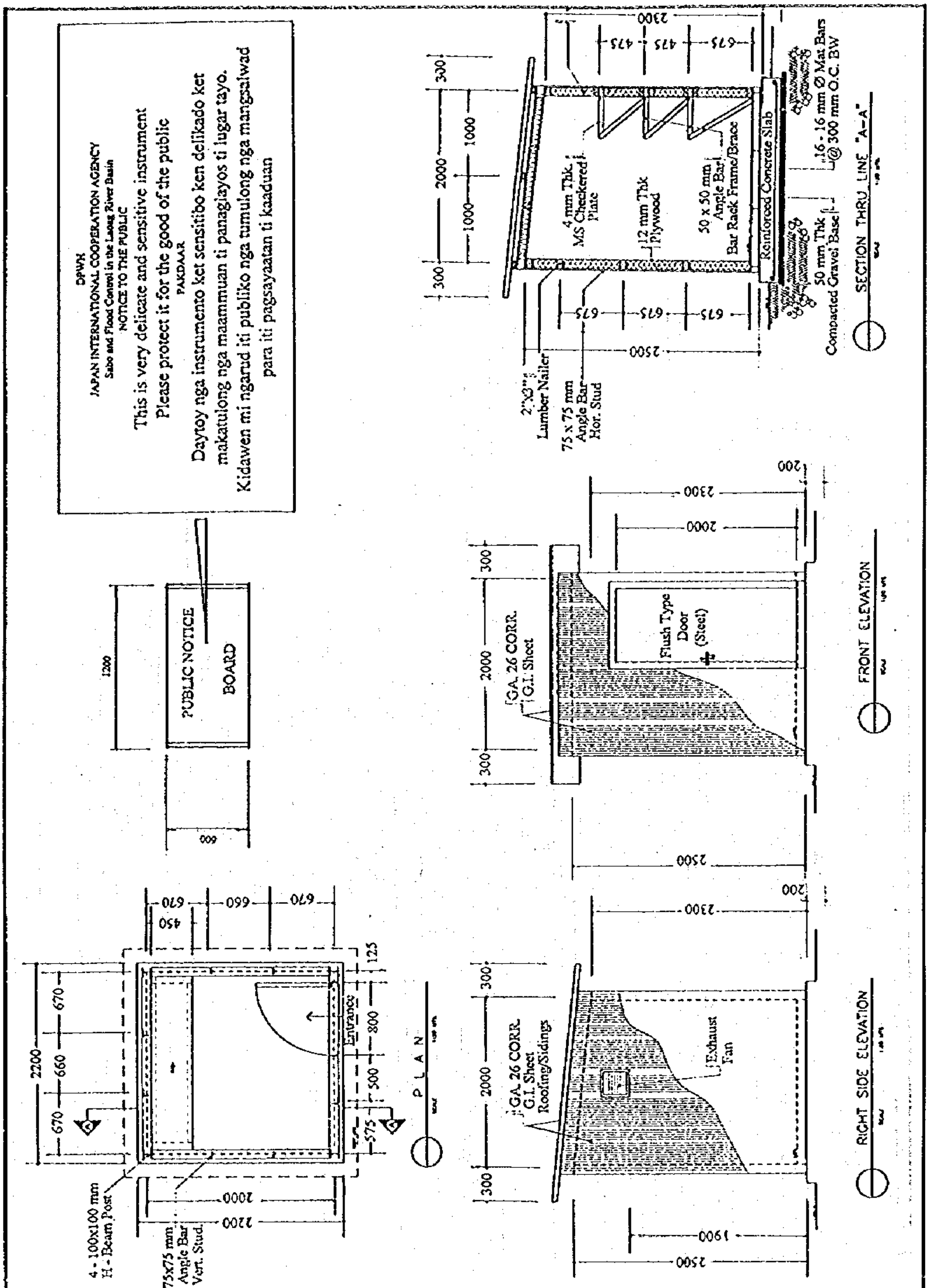


POWER SUPPLY UNIT

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.5.5(1/2) Details of Electric Equipment for Stream Flow Gauge



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. B.5.5(2/2) Details of Electric Equipment for Stream Flow Gauge



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. B.5.6(1/2) Structural Layout of Electric Equipment House for Stream Flow Gauge
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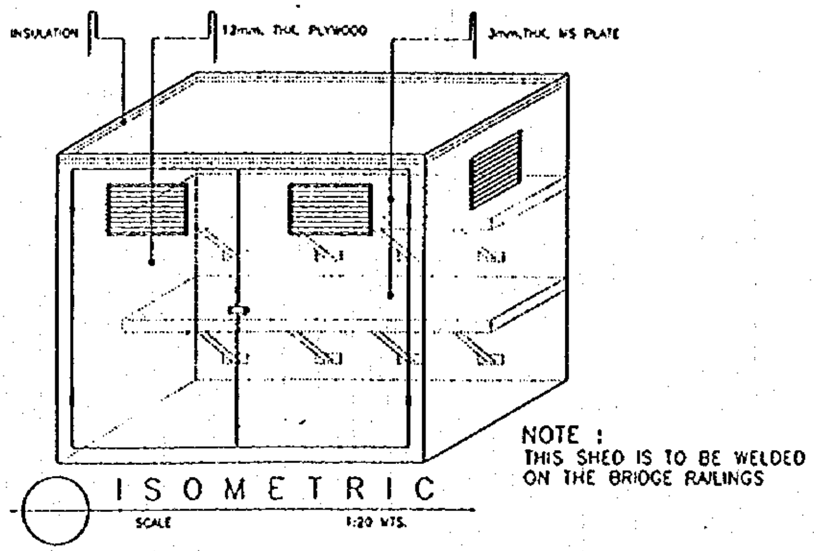

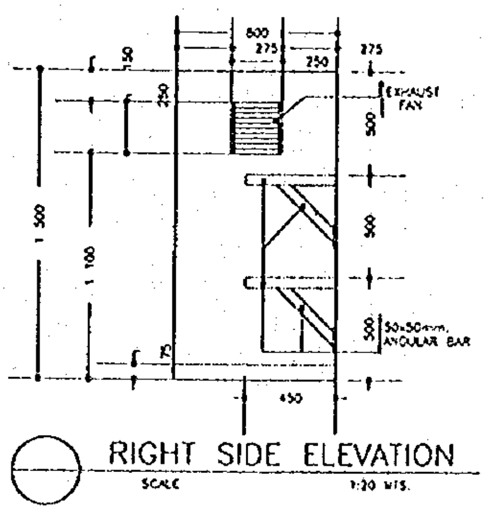

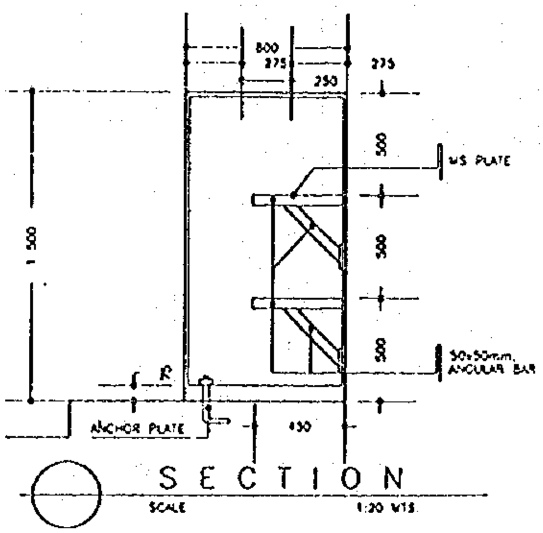

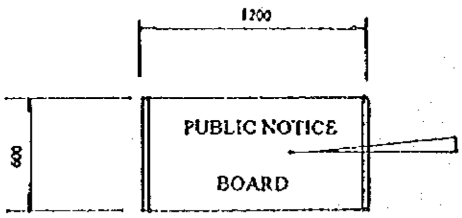

DPWH
JAPAN INTERNATIONAL COOPERATION AGENCY
Sabo and Flood Control in the Laoag River Basin
NOTICE TO THE PUBLIC
This is very delicate and sensitive instrument
Please protect it for the good of the public
PAKDAAR
Daytoy nga instrumento ket sensitibo ken delikado ket
makatulong nga maammuan ti panaglayos ti lugar tayo.
Kidawen mi ngarud iti publiko nga tumulong nga mangsalwad
para iti pagsayaatan ti kaaduan

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. B.5.6(2/2) Structural Layout of Electric Equipment House for Stream Flow Gauge
JAPAN INTERNATIONAL COOPERATION AGENCY	